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Office of Radiation Programs

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr'a
10^{9}	giga	G	jĭ'ga
10^{6}	mega	M	mĕg'a
10^{3}	kilo	k	kĭ'lo
10^{2}	hecto	h	hĕk'to
10	deka	da	dĕk'a
10^{-1}	deci	d	dĕs'i
10^{-2}	centi	c	sĕn'ti
10^{-3}	milli	m	mĭl'i
10^{-6}	micro	μ	mi'kro
10^{-9}	nano	n	năn'o
10^{-12}	pico	p	pē'ko
10^{-15}	femto	f	fĕm'to
10^{-18}	atto	a	ăt'to

SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
Å	angstrom	10^{-10} meter
a	annum, year	
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb.
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/m^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^2	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

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Radiation Data and Reports, a monthly publication of the Environmental Protection Agency, presents data and reports provided by Federal, State, and foreign governmental agencies, and other cooperating organizations. Pertinent original data and interpretive manuscripts are invited from investigators.

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. This responsibility was delegated to the Bureau of Radiological Health, Public Health Service. Pursuant to the Reorganization Plan No. 3 of 1970, effective December 2, 1970, this responsibility was transferred to the Radiation Office of the Environmental Protection Agency which was established by this reorganization.

The Federal agencies listed below appoint their representatives to a Board of Editorial Advisors. Members of the Board advise on general publications policy; secure appropriate data and manuscripts from their agencies; and review those contents which relate to the special functions of their agencies.

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Department of Agriculture
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Environmental Protection Agency
Atomic Energy Commission

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U.S. ENVIRONMENTAL PROTECTION AGENCY

William D. Ruckelshaus, Administrator

Reports

Evaluation of Tritium in Ground and Surface Waters of the Western United States, April 1968-December 1969

James W. Mullins and John L. Stein [1]

In order to establish a baseline for environmental tritium so that any future deviations could be evaluated, a study was conducted to measure current levels of tritium in ground and surface waters of the Western United States. Data are reported for tritium concentrations in surface and ground waters during April 1968-December 1969 in the Western United States including Alaska and Hawaii. Samples were collected by State public health agencies and mailed to the Western Environmental Research Laboratory where they were analysed by liquid scintillation techniques. The concentration of tritium was nondetectable in most ground water samples, while other samples contained as much as 2.6 nCi/liter. Surface water samples ranged from nondetectable to 3.8 nCi/liter. Possible reasons for the range of results, such as altitude and latitude effects, are discussed.

A preliminary study of tritium in surface water was conducted in 1963 to determine the levels of tritium in raw and treated waters collected through the Water Pollution Surveillance Program of the Division of Water Supply and Pollution Control and by the Institutional Total Diet Sampling Program of the Division of Radiological Health, U.S. Public Health Service. Observed tritium concentrations in surface waters varied from nondetectable to 12 nCi/liter (*1*).

Based on these and other findings, a surveillance program was established in May 1964 to measure tritium concentrations in 10 major rivers of the United States. Eight of these stations were downstream from nuclear facilities and two served as baselines. This program was administered by the Eastern Environmental Radiation Laboratory[2] (EERL), Environmental Protection Agency (*2*). Observed tritium concentrations ranged from less than detectable to 32 nCi/liter. The results from this program have been reported periodically in *Radiological Health Data and Reports.*

Purpose and scope

The purpose of this study was to gather data on current levels of tritium in ground and surface waters of the Western United States. The study was necessary to establish the baseline concentration level for environmental tritium, so that future deviations from the baseline could be evaluated.

The study was conducted by the Western Environmental Research Laboratory[3] (WERL), U.S. Environmental Protection Agency. At the initiation of the study, all States west of the Mississippi River, including Alaska and Hawaii, were contacted in order to gain their assistance in locating the actual sampling points and the

[1] Mr. Mullins is and Mr. Stein was with the Technical Services and Environmental Surveillance Programs, Western Environmental Research Laboratory, U.S. Environmental Protection Agency, Las Vegas, Nev. 89114. Mr. Stein is now with the Anheuser-Busch Company, St. Louis, Mo.

[2] Formerly the Southeastern Radiological Health Laboratory of the Public Health Service but renamed the Eastern Environmental Radiation Laboratory following its transfer from the Public Health Service to the U.S. Environmental Protection Agency.

[3] Formerly the Southwestern Radiological Health Laboratory of the Public Health Service but renamed the Western Environmental Research Laboratory following its transfer from the Public Health Service to the U.S. Environmental Protection Agency on December 2, 1970.

collection of samples. Although surface waters were of principal interest, it was left to the discretion of the various State public health and atomic energy agencies whether or not any ground water samples would be collected. Maps showing the locations of the surface and ground water sampling stations selected are shown in figures 1 and 2, respectively.

Procedures

Sample collection procedures were set up to provide quarterly samples during 1968 and 1969. In some cases, stations were sampled only once with new stations selected for subsequent sampling. In other cases, composite samples collected over a period of a month were obtained instead of single grab samples. All sample collection was carried out by State agencies which then forwarded the samples to WERL or EERL for analysis. The first samples were collected in April 1968 and the program was terminated in December 1969.

All samples were purified by distillation and analyzed by liquid scintillation counting as described by Moghissi, et al. (*3*). The minimum detectable concentration (MDC) at WERL is 400 pCi/liter based on 5 ml of sample and 100-minute counting time. The estimated analytical error, based on the 3σ counting error, is 400 pCi/liter for results up to 4 nCi/liter and 10 percent of the measurement above that amount. The MDC at EERL is 200 pCi/liter based on a 5 ml sample size and 200-minute counting time.

Results

A summary of the results for the various sampling stations in the study is presented in table 1. Surface water samples were received from all States participating in the study. Samples were collected from principal streams and various tributaries of the major river basins of the Western United States. Also sampled were numerous lakes and reservoirs. Ground water samples were obtained from the States of

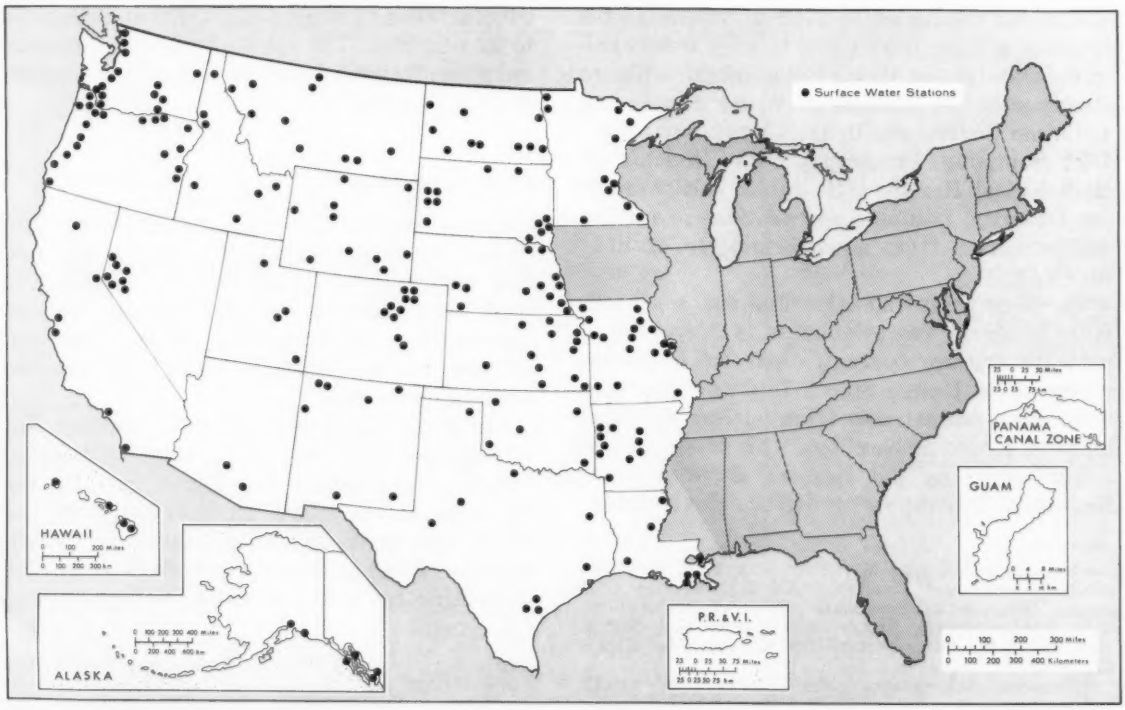

Figure 1. Surface water stations

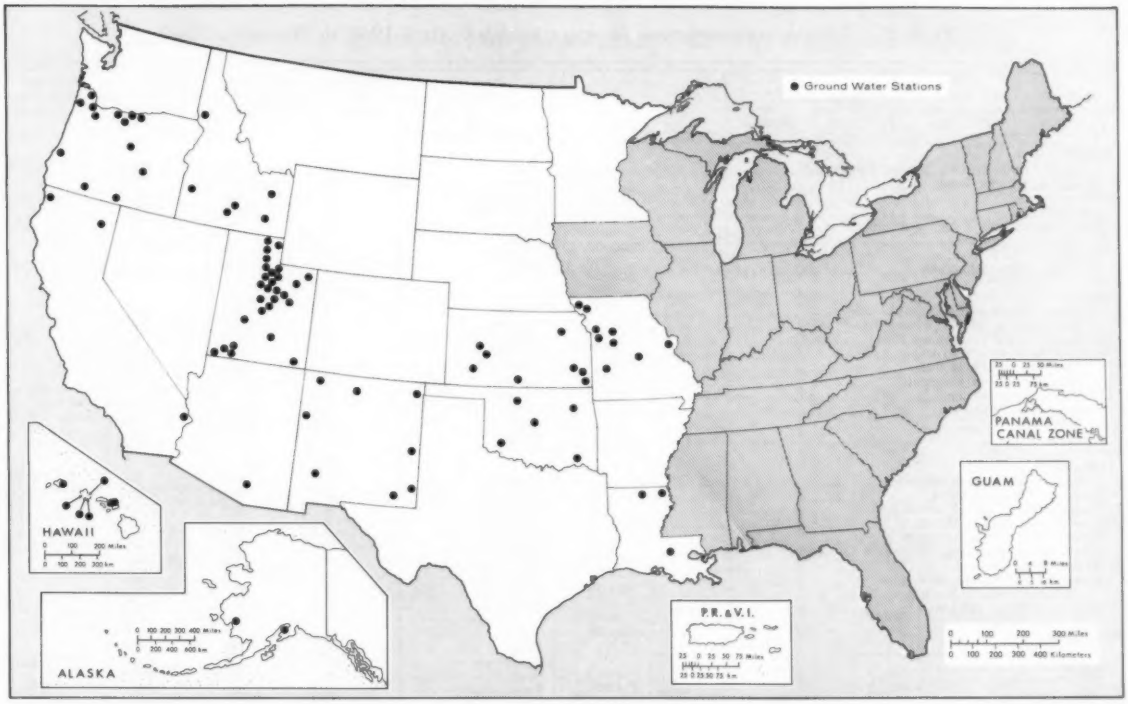

Figure 2. Ground water stations

Alaska, Arizona, California, Hawaii, Idaho, Louisiana, Kansas, Missouri, New Mexico, Oklahoma, Oregon, and Utah. All ground water samples came from wells, springs, or underground catchment systems.

In general, surface waters tended to indicate tritium levels above the MDC. The range of tritium concentrations for all surface samples was <MDC to 3.8 nCi/liter.

Most of the ground water samples showed tritium concentrations below the MDC, however, several samples did show detectable concentrations, one as high as 2.6 nCi/liter. Nearly all States showed at least one station above the MDC. In some cases, samples were taken from distribution systems which have some supply from surface sources. In other instances, samples came from shallow wells which are in close proximity to surface streams which indicated detectable levels of tritium. In this report, no attempt has been made to determine the source of tritium in ground waters.

For purposes of averaging, all values below detectable levels were considered to be zero. For this reason some averages are reported which are below the stated MDC.

Discussion of results—surface water samples

All surface water sample results for each State sampled in the 1968–1969 time period were averaged. Data for 1968 only were available for the States of Arkansas, Louisiana, and Oklahoma. The States were then classified into four categories based upon the average tritium concentration. The map in figure 3 shows the States in the study shaded to indicate the average tritium levels.

Examination of figure 3 discloses that the highest average levels of tritium in surface water occurred in the Mountain States (Colorado, Montana, Utah, and Wyoming) and in the Northern Plains States (Minnesota, North Dakota, and South Dakota). Lesser average concentrations are noted in the bordering States of Idaho and Nebraska. Intermediate levels are found in States still further from the areas of maximum average concentrations; States with intermediate levels are California, Missouri,

Table 1. Tritium concentrations in water samples, April 1968 to December 1969

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Alaska:					
Bethel: Public Health Service hospital	Well	11	<400	<400	0
Chugiak: Peters Creek	Stream	11	1,700	770	1,100
Cordova	Reservoir	9	820	<400	390
Juneau	Reservoir	3	<400	<400	0
Ketchikan: 1287 Tongass Avenue	Lake	1	—	—	510
628 Park Avenue	Lake	1	—	—	0
Sitka: Indian River	Stream	1	—	—	0
Soldotna: Ground source	Well	11	600	<400	90
Arizona:					
Phoenix: Encanto Park golf course	Stream	4	<400	<400	0
Fire Station, 230 E. Roeser Road	Stream	4	<400	<400	0
Squaw Peak Treatment Plant	Stream	4	710	<400	180
21st Avenue and Morton	Stream	4	<400	<400	0
32nd Drive and Myrtle	Stream	4	<400	<400	0
48th Street and Virginia	Stream	4	<400	<400	0
Verde plant effluent	Stream	1	—	—	0
Tucson: Plant No. 1	Well	4	<400	<400	0
Plant No. 3	Well	4	<400	<400	0
Plant No. 4	Well	4	<400	<400	0
Arkansas:[a]					
Arkadelphia: Texaco station	Reservoir	2	400	200	300
Benton: Texaco station	Reservoir	2	400	<200	200
Conway: Stanton's Esso station	Reservoir	2	400	<200	200
Fort Smith: Sands Motel	Reservoir	2	400	200	300
Greenwood: Texaco station	Reservoir	2	400	200	300
Little Rock: Radiological Health Laboratory	Reservoir	2	400	300	350
Mena: Esso station	Reservoir	2	<200	<200	0
Russellville: Phillips 66 station	Reservoir	2	600	600	600
Texarkana: Texaco station	Reservoir	2	200	<200	100
Waldron: Citgo station	Reservoir	2	300	<200	150
California:					
Alturas	Well	6	<400	<400	0
Berkeley	Reservoir	6	570	<400	430
Crescent City	Well	6	<400	<400	0
Los Angeles	Stream/well	6	1,500	<400	250
Metropolitan Water District of Southern California Weymouth Treatment Plant	Stream	5	2,400	1,600	2,000
Needles	Well	6	1,700	<400	870
Redding	Reservoir	6	<400	<400	0
San Diego: Alvarado Treatment Plant	Stream	6	2,400	780	1,500
San Francisco	Reservoir	6	490	<400	230
Tahoe City: 50 miles SW	Lake	3	<400	<400	0
Colorado:					
Boulder: Boulder Creek at 75th Avenue	Stream	7	2,500	1,200	1,700
Eben Fine Park	Stream	7	1,600	1,000	1,300
Brighton: S. Platte River at Hwy. 224	Stream	7	1,600	950	1,200
Colorado Springs: Fountain Creek (above)	Stream	7	1,800	900	1,300
Fountain Creek (below)	Stream	7	1,400	850	1,200
Denver: S. Platte River at Bowles Avenue	Stream	6	1,400	830	1,200
Greeley: Cache La Poudre River	Stream	6	1,800	1,100	1,600
South Platte River at Hwy. 60	Stream	7	2,600	1,000	1,800
South Platte River at Hwy. 66	Stream	7	2,200	1,200	1,500
St. Vrain Creek at Hwy. 66	Stream	7	2,200	1,300	1,800
Hawaii:					
Honolulu: Airport	Well	5	<400	<400	0
Central	Well	5	<400	<400	0
Department of Health	Well	5	<400	<400	0
Kahului: Makuhau Storage	Well	5	<400	<400	0
Kamuela: Waikola Stream, 22 miles north	Stream	5	<400	<400	0
Kuaui Island: Port Allen pier	Well	5	<400	<400	0
Hilo: Pakamaui Storage	Reservoir	5	<400	<400	0
Lahaina: County System	Stream/well	5	<400	<400	0
Lihue: Pua Loke Park	Well	5	<400	<400	0
Pearl City: Hoomalu Street	Well	5	<400	<400	0
Idaho:					
Blackfoot: Public water supply		2	1,800	1,100	1,500
Springfield Lake, 30 miles SW	Lake	6	800	<400	340
Atomic City, 33 miles NW		5	450	<400	90
Boise: Boise River	Stream	6	1,100	660	880
Public water supply	Well	1	—	—	880
Buhl: Public water supply	Well	1	—	—	0
Burley: Snake River at Milner Dam	Stream	5	910	<400	600
Minidoka, 20 miles NE	Well	5	<400	<400	0
Idaho Falls: Snake River	Stream	6	1,100	570	900
Idaho Falls: Public water supply	Well	1	—	—	740
Jerome: Public water supply	Well	6	<400	<400	0
Lewiston: Clearwater River	Stream	1	—	—	1,200
Snake River	Stream	5	1,000	<400	460
Moscow: Public water supply	Well	6	<400	<400	0
Sandpoint: Pend Oreille Lake	Lake	5	1,500	1,000	1,300

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Kansas:					
Baxter Springs: 6 miles SW	Well	1	—	—	0
Spring River	Stream	7	1,100	<400	250
Burlington: Neosho River, 27 miles SE	Stream	1	—	—	560
Cheney: Ninnescah River	Stream	6	750	<400	130
Dighton	Well	1	—	—	660
Dodge City: Arkansas River	Stream	7	720	<400	240
Garden City	Well	1	—	—	0
Glen Elder: Solomon River	Stream	7	840	<400	270
Harper	Well	1	—	—	0
Jetmore	Well	1	—	—	0
Langley: Smokey Hill River	Stream	1	—	—	0
Lecompton: Kansas River	Stream	6	1,100	<400	220
Manhattan	Well	1	—	—	580
Big Blue River	Stream	7	710	<400	100
Oketo: Big Blue River	Stream	7	890	<400	200
Ottawa: Marais des Cygnes River	Stream	6	530	<400	90
Parsons: Neosho River	Stream	7	880	<400	190
Riverton	Well	1	—	—	0
Walnut	Well	1	—	—	0
Winfield: Walnut River	Stream	7	610	<400	170
Louisiana:[a]					
Alexandria: Red River	Stream	1	—	—	300
East Baton Rouge: Well 19	Well	2	<200	<200	0
Farmerville: Well 3	Well	2	800	<200	400
Jonesville: Black River	Stream	2	800	<200	400
Kentwood: Wells	Well	1	—	—	0
Lake Charles: Calcasieu River	Stream	2	400	<200	200
New Orleans	Stream	1	—	—	400
	Stream	1	—	—	0
	Stream	1	—	—	300
Oak Grove: Well 1	Well	2	<200	<200	0
Slidell: West Pearl River	Stream	2	200	<200	100
Minnesota:					
Clearwater: Mississippi River	Stream	8	1,200	680	1,100
Grand Forks: Red Lake River	Stream	8	1,800	600	1,300
Eveleth: St. Mary's Lake	Lake	8	1,800	<400	1,400
Fairmont: Budd Lake	Lake	8	1,300	600	900
Hallock: South Fork, Two Rivers	Stream	8	1,200	<400	900
International Falls: Rainy River	Stream	7	2,700	1,400	2,000
Minneapolis: Mississippi River	Stream	7	1,200	610	1,000
Pine City: St. Croix River, 9 miles east	Stream	8	750	<400	230
Red Wing: Mississippi River at Lock & Dam 3	Stream	2	1,200	960	1,100
St. Paul: Vadnais Lakes	Lake	8	1,800	500	1,000
Winona: Mississippi River, 10 miles east	Stream	6	800	500	700
Missouri:					
Boonville: Public water supply	Stream	5	1,400	670	1,100
Carrollton	Well	1	—	—	0
Columbia		1	—	—	0
Concordia	Well	1	—	—	800
Eldorado	Well	1	—	—	0
Hannibal: New London public water supply	Stream	6	940	<400	160
Independence	Well	1	—	—	0
Jefferson City	Well	7	1,500	<400	360
Joplin: Public water supply	Stream	6	1,100	<400	180
Kansas City	Stream	5	1,400	<400	910
Grain Valley, 10 miles east	Stream	2	1,700	<400	850
Kirksville	Lake	7	970	<400	480
Macon	Lake	1	—	—	0
Maitland	Well	1	—	—	0
Maryville	Stream	1	—	—	0
Moberly	Lake	1	—	—	0
Mound City	Well	1	—	—	0
Platte City	Well	1	—	—	2,600
Poplar Bluff: Public water supply	Stream	6	<400	<400	0
Sedalia	Stream/well	1	—	—	690
Springfield: Public water supply	Lake	6	560	<400	90
St. Joseph	Stream	7	2,700	830	1,600
St. Louis	Stream	2	1,300	<400	650
St. Louis County	Stream	5	1,800	<400	850
Fenton, 10 miles south	Stream	1	—	—	0
Union	Stream/well	1	—	—	0
Montana:					
Bozeman: Bozeman Creek	Stream	8	1,700	640	1,100
Chinook: Milk River	Stream	8	1,800	1,000	1,400
Forsyth: Yellowstone River	Stream	8	3,500	1,100	1,800
Fort Benton: Missouri River	Stream	8	1,400	430	910
Hardin: Big Horn River	Stream	8	1,900	<400	1,200
Helena: Prickley Pear Creek	Stream	6	1,800	670	1,200
Kalispell: Flathead River	Stream	8	1,600	770	1,100
Laurel: Yellowstone River	Stream	8	1,700	750	1,200
Missoula: Rattlesnake Creek	Stream	8	1,200	<400	810
Noxon: Columbia River, Clark Fork	Stream	7	1,500	760	1,100

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Nebraska:					
Benkelman: Republican River	Stream	7	1,400	<400	200
Blair: Missouri River	Stream	6	2,200	870	1,700
Brownville: Missouri River	Stream	7	2,300	520	1,500
Crete: Big Blue River	Stream	6	560	<400	90
Niobrara: Niobrara River	Stream	7	<400	<400	0
Norfolk: Missouri River, 59 miles north	Stream	7	2,200	<400	1,400
North Platte: North Platte River	Stream	7	1,700	<400	580
Ogallala: South Platte River, 20 miles west	Stream	7	1,400	<400	660
Omaha: Missouri River	Stream	7	2,400	960	1,800
Rulo: Missouri River	Stream	7	2,100	550	1,500
Schuyler: Platte River	Stream	7	830	<400	210
St. Paul: North Loup River	Stream	7	500	<400	140
Nevada:					
Minden: Carson River, 10 miles SW	Stream	6	510	<400	170
Carson River, East Fork at Hatchery	Stream	6	560	<400	170
Reno: Steamboat Ditch, 15 miles south	Stream	6	<400	<400	0
Verdi: Truckee River, SW of Ceresola Ranch	Stream	6	<400	<400	0
Truckee River, SW of Farad, Calif	Stream	6	<400	<400	0
Truckee River, SW of Lockwood	Stream	6	<400	<400	0
Wabuska: Walker River at J & J Ranch	Stream	6	480	<400	150
Weeks: Carson River	Stream	6	480	<400	240
Yerington: Walker River, West Fork	Stream	6	520	<400	240
Walker River, East Fork	Stream	6	570	<400	170
New Mexico:					
Carlsbad: Pecos River	Stream	2	<400	<400	0
Public water supply	Well	7	<400	<400	0
Clayton	Well	6	<400	<400	0
Clovis	Well	7	<400	<400	0
Espanola: Public water supply	Well	7	<400	<400	0
Rio Grande	Stream	1	—	—	590
Farmington:	Well	3	1,800	1,400	1,600
Animas River	Stream	3	980	660	850
San Juan River	Stream	2	1,300	500	900
Gallup: Well Field	Well	7	<400	<400	0
Rio Puerce	Stream	1	—	—	570
Hobbs	Well	5	<400	<400	0
Las Cruces: Public water supply	Well	1	—	—	0
Rio Grande	Stream	7	780	<400	350
Raton: Cimarron River, 64 miles SW	Stream	1	—	—	1,100
Silver City	Well	7	<400	<400	0
North Dakota:					
Bismarck: Missouri River	Stream	5	2,200	1,300	1,800
Fargo: Red River	Stream	5	1,900	1,100	1,500
Grand Forks: Red River	Stream	5	1,500	1,200	1,300
Jamestown: James River Dam	Stream	5	2,000	840	1,200
Mandan: Heart River	Stream	5	1,400	1,000	1,200
Medora: Little Missouri River	Stream	4	1,400	<400	900
Minot: Souris River	Stream	5	1,900	500	1,500
Regent: Cannonball River	Stream	4	1,100	<400	690
Valley City: Sheyenne River	Stream	5	1,100	520	840
Williston: Missouri River	Stream	4	1,500	<400	710
Oklahoma:[a]					
Altus: Water Department	Lake	1	—	—	300
Blair	Well	1	—	—	0
Broken Bow	Stream	1	—	—	0
Enid	Well	1	—	—	0
Fort Supply	Lake	1	—	—	0
Jenks	Well	1	—	—	200
Nichols Hills	Well	1	—	—	0
Oklahoma City: Lake Heffner	Lake	1	—	—	0
Tulsa	Lake	1	—	—	0
Valliant	Well	1	—	—	0
Oregon:					
Albany: Santiam River, 7 miles north	Stream	1	—	—	0
Baker: Powder River	Stream	3	710	570	650
Bonneville: Bonneville well	Well	2	750	450	600
Brookings: Rogue River, 31 miles north	Stream	1	—	—	0
Columbia City: St. Helen's well	Well	2	710	570	640
The Dalles: Columbia River	Stream	1	—	—	970
Chenowith Irrigation District	Well	1	—	—	0
Mark s well	Well	2	650	<400	330
Elgin: Grande Ronde River	Stream	3	660	<400	440
Elkton: Umpqua River	Stream	1	—	—	0
Goble: Columbia River	Stream	1	—	—	750
Hines: Ed Hines mill	Well	1	—	—	0
Hood River: Graham's well	Well	2	660	660	660
John Day: John Day River	Stream	2	430	<400	220
Klamath Falls: Wagnor's well	Well	1	—	—	0
Lakeview: Lakeview well	Well	1	—	—	0
Myrtle Point: Coquille River, North Fork	Stream	1	—	—	0

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Oregon: continued					
North Bend: Douglas Fir Chip	Well	1	—	—	540
Ontario: Malheur River	Stream	2	530	<400	270
Snake River	Stream	3	660	570	610
Portland: Columbia River	Stream	1	—	—	620
Willamette River	Stream	1	—	—	0
Bull Run Headworks Reservoir No. 1	Lake	1	—	—	500
Columbia School	Well	2	<400	<400	0
Portland Rendering Company	Well	1	—	—	0
Prineville: Lamanta well	Well	1	—	—	0
Springfield: McKenzie River	Stream	1	—	—	0
Willamette: Public water supply	Stream	1	—	—	0
Tillamook: Fairview Water District	Well	1	—	—	440
Wilson River	Stream	1	—	—	0
Umatilla: Columbia River	Stream	1	—	—	1,100
Umatilla River	Stream	1	—	—	880
South Dakota:					
Aberdeen: James River, 35 miles NE	Stream	6	1,300	<400	900
Hot Springs: Cheyenne River, 21 miles SW	Stream	4	1,500	610	1,100
Mobridge: Missouri River	Stream	6	2,100	1,400	1,900
Rapid City: Rapid Creek at Johnson Siding	Stream	3	1,700	1,000	1,400
Rapid Creek, 18 miles SE	Stream	6	1,500	<400	1,000
Cheyenne River, 40 miles east	Stream	5	1,700	<400	1,100
Rapid Creek at Poctola Reservoir	Stream	3	1,600	<400	900
Sioux Falls: Big Sioux Path north	Stream	6	900	<400	610
Big Sioux Path south	Stream	6	1,400	650	920
Big Sioux, 70 miles SE	Stream	4	600	<400	150
Missouri River, 70 miles SE	Stream	5	2,000	<400	1,400
Yankton: James River, 5 miles east	Stream	5	2,700	680	1,400
Texas:*					
Colorado City: Colorado River	Stream	7	<200	<200	0
Conroe: San Jacinto River	Stream	7	<200	<200	0
Girwin: Pecos River	Stream	6	<200	<200	0
Goliad: San Antonio River	Stream	4	<200	<200	0
Port Neches	Stream	7	<200	<200	0
Refugio: Mission River	Stream	7	<200	<200	0
Tilden: Nueces River	Stream	7	<200	<200	0
Wichita Falls: Red River	Stream	6	<200	<200	0
Lower Gulf Coast	Stream	2	<200	<200	0
Canadian River	Stream	6	<200	<200	0
Utah:					
Alton: Palmer residence	Spring	1	—	—	0
Blanding: Cliff Palace motel	Reservoir	1	—	—	1,100
Bluff	Well	1	—	—	0
Brigham City: Health Department	Spring/well	1	—	—	0
Castle Dale: Emery Courthouse	Reservoir	1	—	—	1,400
Cedar Fort: Cedar Fort school	Spring/well	1	—	—	0
Clear Creek: Jensen residence	Spring	1	—	—	0
Delta: Delta City building	Well	1	—	—	0
Duchesne: Duchesne Courthouse	Well	1	—	—	0
Elberta: Mitarai residence	Spring	1	—	—	0
Ephraim: Municipal swimming pool	Spring/well	1	—	—	1,100
Fairview: WW Trailer Park	Spring/well	1	—	—	590
Gunnison: City building	Spring	1	—	—	0
Heber: Olsen residence	Spring/well	1	—	—	0
La Verkin: Gateway Trailer Court	Spring	1	—	—	0
Milford: Hong Kong Cafe	Well	1	—	—	0
Mona: Phillips 66 station, Hwy 91	Spring	1	—	—	0
Nephi: Juab City building	Spring/well	1	—	—	0
Oakley: American station	Spring	1	—	—	0
Park City: Treasure Mountain Inn	Spring	1	—	—	0
Peterson: Richins residence	Reservoir/well	1	—	—	800
Price: Silvagni building	Reservoir/spring	1	—	—	0
Randolph: Rich Courthouse	Spring	1	—	—	0
Red Wash: Warehouse	Well	1	—	—	1,300
Santa Clara: Santa Clara mercantile	Spring	1	—	—	0
South Monroe: Jensen residence	Spring/well	1	—	—	2,100
Torrey: Smith residence	Spring	1	—	—	0
Tremonton: Lamb's Service station, 15 miles north	Spring	1	—	—	0
Virgin: Flanigan residence	Spring	1	—	—	0
Wanship: Spring Chicken Inn	Well	1	—	—	0
Washington:					
Bellingham: Whatcom Lake	Lake	6	1,100	<400	660
Kent: Cedar River, 25 miles east	Stream	4	470	<400	230
Kelso: Toutle River, 12 miles north	Stream	1	—	—	590
Longview: Columbia River	Stream	6	1,700	<400	710
Lewis River, 20 miles south	Stream	2	690	550	620
Mount Vernon: Skagit River	Stream	2	1,100	520	810
McNary Dam: Columbia River	Stream	5	1,400	460	910
Pasco: Columbia River	Stream	4	1,300	930	1,000
Snake River	Stream	3	750	500	600
Puyallup: Puyallup River	Stream	4	<400	<400	0
Richland: Columbia River, untreated	Stream	4	1,100	710	940
Columbia River, treated	Stream	3	1,300	1,000	1,200
Snohomish: Snohomish River	Stream	1	—	—	1,400
Spokane: Spokane River, 25 miles NW	Stream	6	1,400	610	830
Vancouver: Columbia River	Stream	5	920	700	860

See footnotes at end of table.

Table 1. Tritium concentrations in water samples, April 1968 to December 1969—continued

Location	Source	Number of samples	Maximum concentration (pCi/liter)	Minimum concentration (pCi/liter)	Average concentration (pCi/liter)
Wyoming:					
Alpine: Snake River	Stream	8	2,300	560	1,300
Green River: Green River	Stream	8	1,700	<400	1,300
Hulett: Belle Fourche River	Stream	8	1,700	<400	1,100
Kane: Big Horn River	Stream	8	2,100	1,100	1,500
Laramie: Laramie River	Stream	8	1,500	<400	1,100
Medicine Bow: Medicine Bow River	Stream	8	3,800	<400	1,100
Muddy Gap: Sweetwater River	Stream	8	1,600	520	1,000
Riverton: Big Wind River	Stream	8	1,900	1,000	1,500
Shoshone: Poison Creek	Stream	8	1,600	810	1,300
Torrington: North Platte River	Stream	8	1,600	<400	1,000

[a] Analyses performed at the Eastern Environmental Radiation Laboratory.

New Mexico, and Washington of the contiguous States, and Alaska. The lowest levels of tritium were observed in areas contiguous to those where intermediate values were noted. These States included Arkansas, Arizona, Kansas, Louisiana, Nevada, Oklahoma, Oregon, and Texas. In addition, very low levels of tritium in surface water were determined in samples from Hawaii.

The principal contributors of tritium in the environment are cosmic-ray fast neutron bombardment of nitrogen and atmospheric testing of nuclear and especially thermonuclear devices. Secondary contributors include various nuclear facilities. Although atmospheric testing of nuclear devices has almost ceased in recent years, this input is largely responsible for the levels of tritium noted in ground and surface waters (*4*).

The phenomenon which accounts for the higher tritium levels observed in the Mountain and Plains States is not fully understood. Previous studies have noted a latitude effect in which tritium concentrations in precipitation increase generally with increasing latitude. It has also been observed that surface stations at higher altitudes generally show somewhat higher levels of tritium (*5*).

It is known that cosmic-ray activity, including neutron activity, increases rapidly with altitude. It is not known, however, if variance in the natural production rate of tritium with change in altitude is solely responsible for the "altitude effect" observed.

One explanation for both the altitude and latitude effects is that evaporated surface ocean water provides a reservoir of low tritium con-

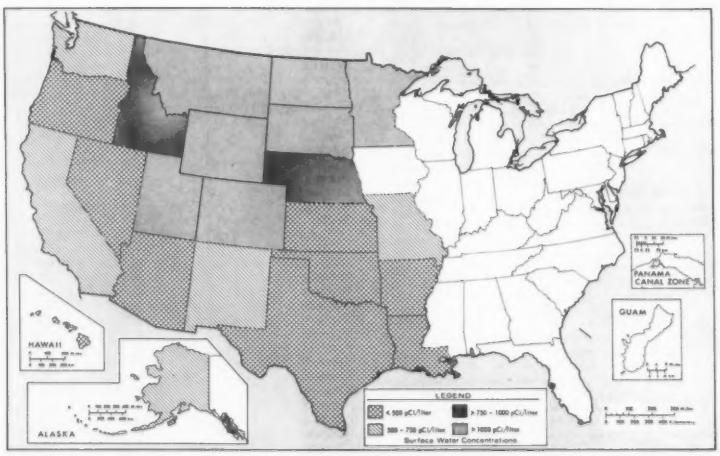

Figure 3. Surface water concentrations

tent atmospheric water vapor for dilution of tritium fallout. Hence, areas along the coasts would be likely to show lower tritium concentrations. Such vapor carried from the Gulf of Mexico across the Central and Eastern United States by prevailing winds might also serve to reduce concentrations in these areas. Inland mountain areas, however, would have no such opportunity for dilution (*6*, *7*).

Other factors influencing tritium concentrations in water, such as seasonal variations of tritium concentration in precipitation, are known (*8*). However, no seasonal or precipitation correlations could be derived from this study.

Ground water samples

Generally, ground water from deep or geologically isolated aquifers does not contain measurable concentrations of tritium. Shallow wells may, however, show detectable levels. Tritium may reach such wells by percolation of rainwater or nearby surface waters which contain tritium. Less common sources of tritium in ground water are effluent from nuclear facilities and tracer studies.

In the majority of the stations sampled during the study, tritium was not detected. However, 17 widely scattered stations had one or more samples with detectable tritium.

Summary

Based upon this study of tritium in ground and surface waters of the Western United States, the following observations are made:

1. The concentration of tritium in ground water ranged from <MDC to 2.6 nCi/liter.

2. The concentration of tritium in surface water ranged from <MDC to 3.8 nCi/liter.

3. The majority of ground water samples did not show detectable tritium concentrations.

4. No tritium concentrations in individual samples were greater than 0.4 percent of the applicable radiation protection standard as recommended by the National Council on Radiation Protection and Measurements (*9*).

Acknowledgement

The assistance of the various State agencies cooperating in this study through the selection of sampling sites, the collection of samples, and the verification of basic data is gratefully acknowledged.

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SECTION I. MILK AND FOOD

Milk Surveillance, October 1971

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Office of Radiation Programs. U.S. Environmental Protection Agency, and the Office of Food Sanitation, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations: 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiation Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Environmental Protection Agency)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations.

The sampling locations that make up the networks presently reporting in *Radiation Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of

Figure 1. Milk sampling networks in the Western Hemisphere

metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variations, expressed in terms of 2 standard deviations (2σ), for these elements are 1.16 $\pm$ 0.08 g/liter for calcium and 1.51 $\pm$ 0.21 g/liter for potassium. These figures are averages of data from the PMN for May 1963-March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national, and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Office of Radiation Programs conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted during May-July 1970, with 28 laboratories participating in an experiment on milk samples containing known concentrations of strontium-89, strontium-90, iodine-131, cesium-137, and barium-140 (*5*). Of the 18 laboratories producing data for the networks reporting in *Radiation Data and Reports*, 13 participated in the experiment.

The accuracy results of this experiment are shown in table 1. In general, considerable improvement is needed, especially in the accuracy measurements. These possible differences should be kept in mind when considering the integration of data from the various networks.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methods, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the net-

Table 1. Distribution of mean results, quality control experiment

Isotope and known concentration in milk		Number of laboratories in each category			
		Acceptable[a]	Warning level[b]	Unacceptable[c]	Total
Strontium-89:	High (258 pCi/liter)	7 (44%)	1 (6%)	8 (50%)	16
	Low (15 pCi/liter)	11 (69%)	3 (19%)	2 (12%)	16
Strontium-90:	Intermediate (79.4 pCi/liter)	13 (57%)	4 (17%)	6 (26%)	23
	Low (32.0 pCi/liter)	5 (25%)	4 (20%)	11 (55%)	20
Iodine-131:	High (507 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (49 pCi/liter)	16 (64%)	3 (12%)	6 (24%)	25
Cesium-137:	High (259 pCi/liter)	20 (74%)	3 (11%)	4 (15%)	27
	Low (53 pCi/liter)	17 (66%)	5 (19%)	4 (15%)	26
Barium-140:	High (302 pCi/liter)	18 (67%)	2 (7%)	7 (26%)	27
	Low (33 pCi/liter)	23 (92%)	0	2 (8%)	25

[a] Measured concentration equal to or within 2σ of the known concentration.
[b] Measured concentration outside 2σ and equal to or within 3σ of the known concentration.
[c] Measured concentration outside 3σ of the known concentration.

works have been referenced in earlier reports appearing in *Radiological Health Data and Reports.*

A previous article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and an earlier data article for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. Many networks are analyzing composite samples on a quarterly basis for certain nuclides. The frequency of collection and analysis varies not only among the networks but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short periods of time, and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data in table 2 show whether raw or pasteurized milk was collected. An analysis (*7*) of raw and pasteurized milk samples collected during January 1964 to June 1966 indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant (*7*). Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard-deviation counting errors or 2-standard-deviation total analytical errors from replicate analyses (*3*). The practical reporting level reflects analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases, the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurements equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical error or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2 standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥ 50 pCi/liter;
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥ 20 pCi/liter;
Iodine-131, Cesium-137, Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥ 100 pCi/liter.

For iodine-131, cesium-137, and barium-140, there is one exception for these precision error

Table 2. Concentrations of radionuclides in milk for October 1971 and the 12-month period November 1970 through October 1971

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:						
Ala:	Montgomery [c]	P	8	6	0	10
Alaska:	Palmer [c]	P	5	5	0	12
Ariz:	Phoenix [c]	P	0	0	0	0
Ark:	Little Rock [c]	P	11	12	18	12
Calif:	Sacramento [c]	P	2	1	0	0
	San Francisco [c]	P	0	3	0	0
	Del Norte	P	12	14	13	11
	Fresno	P	0	2	0	2
	Humboldt	P	3	4	0	5
	Los Angeles	P	0	2	0	1
	Mendocino	P	3	6	12	6
	Sacramento	P	0	3	0	3
	San Diego	P	0	1	0	2
	Santa Clara	P	0	2	10	3
	Shasta	P	3	3	0	5
	Sonoma	P	0	3	0	5
Colo:	Denver [c]	P	7	5	13	7
	East	R	NA		NA	
	Northeast	R	NA		NA	
	Northwest	R	NA		NA	
	South Central	R	NA		NA	
	Southeast	R	NA		NA	
	Southwest	R	NA		NA	
	West	R	NA		NA	
Conn:	Hartford [c]	P	6	7	0	9
	Central	P	8	7	9	14
Del:	Wilmington [c]	P	6	8	0	5
D.C:	Washington [c]	P	7	8	0	8
Fla:	Tampa [c]	P	7	5	54	44
	Central	R	7	7	53	41
	North	R	22	10	12	24
	Northeast	R	12	7	23	32
	Southeast	R	8	7	68	62
	Tampa Bay area	P	9	6	46	44
	West	R	NA	10	16	20
Ga:	Atlanta [c]	P	9	10	15	14
Hawaii:	Honolulu [c]	P	5	2	0	2
Idaho:	Idaho Falls [c]	P	4	5	0	6
Ill:	Chicago [c]	P	8	7	0	9
Ind:	Indianapolis [c]	P	6	7	0	5
	Central	P	8	8	10	12
	Northeast	P	9	9	15	15
	Northwest	P	10	10	15	14
	Southeast	P	8	10	15	12
	Southwest	P	10	10	10	13
Iowa:	Des Moines [c]	P	6	5	0	2
	Iowa City	P	8	7	0	14
	Des Moines	P	6 (3)	7	13	13
	Spencer	P	NS		NS	
	Little Cedar	P	9	8	11	13
Kans:	Wichita [c]	P	7	7	0	2
	Coffeyville	P	8	9	14	15
	Dodge City	P	5	7	0	6
	Falls City, Nebr	R	NS		NS	
	Hays	P	8	10	16	8
	Kansas City	P	9	9	11	14
	Topeka	P	6	9	16	11
	Wichita	P	8	11	0	11
Ky:	Louisville [c]	P	9	9	0	4
La:	New Orleans [c]	P	13	14	14	20
Maine:	Portland [c]	P	7	9	17	21
Md:	Baltimore [c]	P	8	8	0	6
Mass:	Boston [c]	P	5	9	0	15
Mich:	Detroit [c]	P	6	7	0	11
	Grand Rapids [c]	P	7	8	0	10
	Bay City	P	NS	6	NS	17
	Charlevoix	P	8	10	17 (3)	16
	Detroit	P	6	7	14	9
	Grand Rapids	P	4	7	12	11
	Lansing	P	13	8	16 (2)	16
	Marquette	P	11	10	16 (2)	23
	Monroe	P	4	5	0 (2)	4
	South Haven	P	5	7	0 (5)	11
Minn:	Minneapolis [c]	P	9	8	0	14
	Bemidji	P	12	8	22	21
	Duluth	P	16	17	22	27
	Fergus Falls	P	8	8	11	12
	Little Falls	P	6	5	0	0
	Mankato	P	16	11	20	28
	Minneapolis	P	11	12	12	19

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1971 and the 12-month period November 1970 through October 1971—continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)			
			Strontium-90		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average
UNITED STATES:—Continued						
Minn:	Rochester	P	8	7	16	22
	Worthington	P	6	6	11	12
Miss:	Jackson [c]	P	11	12	14	10
Mo:	Kansas City [c]	P	12	8	0	6
	St. Louis [c]	P	8	6	0	5
Mont:	Helena [c]	P	3	6	0	10
Nebr:	Omaha [c]	P	3	7	0	4
Nev:	Las Vegas [c]	P	4	2	0	1
N.H:	Manchester [c]	P	8	8	18	21
N.J:	Trenton [c]	P	7	8	13	10
N. Mex:	Albuquerque [c]	P	3	3	0	0
N.Y:	Buffalo [c]	P	6	7	0	11
	New York City [c]	P	7	8	0	13
	Syracuse [c]	P	7	7	0	10
	Albany	P	6 (3)	6	[d]0 (4)	[d]0
	Buffalo	P	NS		[d]0	[d]0
	Massena	P	7 (2)	7	[d]0 (2)	[d]0
	New York City	P	NS		[d]0	[d]0
	Syracuse	P	NS		[d]0	[d]0
N.C:	Charlotte [c]	P	10	11	0	12
N. Dak:	Minot [c]	P	6	9	19	11
Ohio:	Cincinnati [c]	P	7	7	0	2
	Cleveland [c]	P	6	7	12	9
Okla:	Oklahoma City [c]	P	7	6	13	9
Oreg:	Portland [c]	P	5	5	11	7
	Baker	P	NA	3	[d]0	[d]3
	Coos Bay	P	NA	5	[d]0	[d]7
	Eugene	P	NA	2	[d]0	[d]2
	Medford	P	NA	2	[d]0	[d]3
	Portland composite	P	NA	6	17	[d]6
	Portland local	P	NA	4	[d]0	[d]10
	Redmond	P	NA	3	[d]0	[d]2
	Tillamook	P	NA	5	23	[d]13
Pa:	Philadelphia [c]	P	7	8	0	9
	Pittsburgh [c]	P	9	11	0	11
	Dauphin	P	4	6	0	12
	Erie	P	8	7	0	13
	Philadelphia	P	6	8	33	17
	Pittsburgh	P	NA	10	20	17
R.I:	Providence [c]	P	7	8	0	16
S.C:	Charleston [c]	P	10	9	12	15
S. Dak:	Rapid City [c]	P	6	6	0	5
Tenn:	Chattanooga [c]	P	9	9	0	10
	Memphis [c]	P	8	7	12	9
	Chattanooga	P	NA	8	11	15
	Clinton	R	NA	9	0	14
	Fayetteville	R	NA	6	0	11
	Kingston	R	NA	7	0	14
	Knoxville	R	NA	9	0	12
	Lawrenceburg	R	NA	5	0	3
	Nashville	R	NA	7	0	12
	Pulaski	R	NA	8	0	3
Tex:	Austin [c]	P	3	1	0	0
	Dallas [c]	P	6	6	0	5
	Amarillo	R	NS	3	NS	2
	Corpus Christi	R	NS	4	NS	0
	El Paso	R	NS	3	NS	0
	Fort Worth	R	3	4	0	0
	Harlingen	R	4	3	0	0
	Houston	R	8	8	0	11
	Lubbock	R	NS	3	NS	0
	Midland	R	2	3	0	0
	San Antonio	R	NS	4	NS	0
	Texarkana	R	NS		NS	
	Tyler	R	NS	16	NS	16
	Uvalde	R	NS		NS	
	Wichita Falls	R	NS	6	NS	4
Utah:	Salt Lake City [c]	P	4	5	0	15
Vt:	Burlington [c]	P	6	6	11	14
Va:	Norfolk [c]	P	10	9	0	6
Wash:	Seattle [c]	P	6	5	14	5
	Spokane [c]	P	6	6	0	4
	Benton County	R	NS	1	NS	2
	Franklin County	R	0	4	10	7
	Sandpoint, Idaho	R	11	13	21	22
	Skagit County	R	6	8	0	12
W. Va:	Charleston [c]	P	4	7	0	8
Wisc:	Milwaukee [c]	P	6	6	0	10
Wyo:	Laramie [c]	P	2	4	0	1

See footnotes at end of table.

Table 2. Concentrations of radionuclides in milk for October 1971 and the 12-month period November 1970 through October 1971—continued

Sampling location	Type of sample [a]	Radionuclide concentration (pCi/liter)			
		Strontium-90		Cesium-137	
		Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA:					
Alberta: Calgary	P	NA		NA	
Edmonton	P	NA		25	24
British Columbia: Vancouver	P	NA		30	24
Manitoba: Winnipeg	P	NA		28	23
New Brunswick: Fredericton	P	NA		18	24
Newfoundland: St. John's	P	NA		33	31
Nova Scotia: Halifax	P	NA		23	24
Ontario: Ottawa	P	NA		29	33
Sault Ste. Marie	P	NA		26	26
Thunder Bay	P	NA		14	15
Toronto	P	NA		15	13
Windsor	P	NA		15	12
Quebec: Montreal	P	NA		18	19
Quebec	P	NA		31	30
Saskatchewan: Regina	P	NA		14	15
Saskatoon	P	NA		20	18
CENTRAL AND SOUTH AMERICA:					
Colombia: Bogota	P	0	2	0	0
Chile: Santiago	P	0	0	0	2
Ecuador: Guayaquil	P	0	0	0	0
Jamaica: Kingston	P	NS	5	NS	83
Venezuela: Caracas	P	0	1	0	0
Canal Zone: Cristobal [c]	P	0	1	14	9
Puerto Rico: San Juan [c]	P	6	4	11	11
PMN network average [c]		6	7	5	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:
Iodine-131: Colorado—25 pCi/liter Cesium-137: Colorado—25 pCi/liter Strontium-90: New York—3 pCi/liter
Michigan—14 pCi/liter New York—20 pCi/liter
Oregon—15 pCi/liter Oregon—15 pCi/liter

[e] This entry gives the average radionuclide concentrations for the Pasteurized Milk Network stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiation Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions was presented in the December 1970 issue of *Radiological Health Data and Reports.*

Data reporting format

Table 2 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiation Data and Reports.* The relationship between the PMN stations and the State stations is shown in figure 2. The first column under each of the reported radionuclides gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radio-

nuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12 monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 2, surveillance results are given for strontium-90 and cesium-137 for October 1971 and the 12-month period, November 1970 to October 1971. Except where noted, the monthly average represents a single sample for the station. Strontium-89, iodine-131 and barium-140 data have been omitted from table 2 since levels at the great majority of the stations for October 1971 were below the respective practical reporting levels. Table 3 gives monthly averages for those stations at which strontium-89, iodine-131, and barium-140 were detected.

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for October 1971, and the highest 12-month average was 17 pCi/liter (Duluth, Minn.) representing 8.5 percent of the Federal Radiation Council radiation protection guide. Cesium-137 monthly averages ranged from 0 to 68 pCi/liter in the United States for October 1971, and the highest 12-month average was 62 pCi/liter (Southeast Florida), representing 1.7 percent of the value derived from the recommendations given in the Federal Radiation Council report. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*8*) and Jamaica.

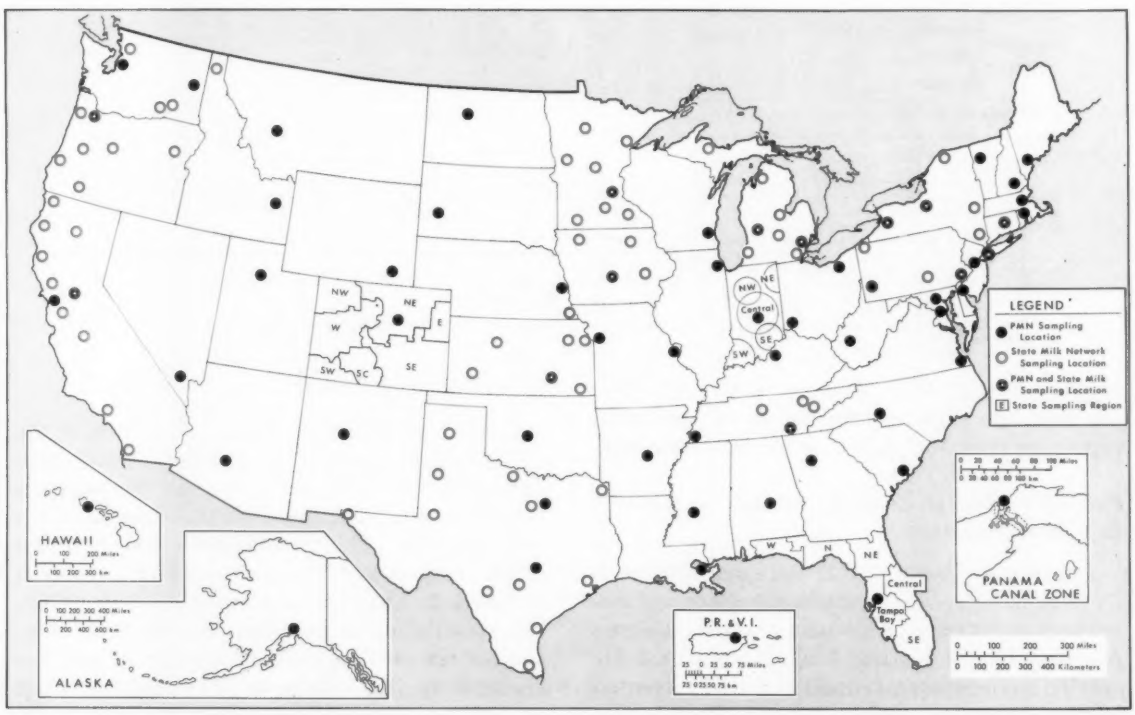

Figure 2. State and PMN milk sampling stations in the United States

Table 3. Strontium-89, iodine-131, and barium-140 in milk, October 1971 [a]

Sampling location		Concentration (pCi/liter)	
		Strontium-89	Barium-140
Calif:	Del Norte (State)	6	14
Kans:	Wichita (State)		
N. Dak:	Minot (PMN)	11	
Chile:	Santiago (PAHO)	8	
Ecuador:	Guayaquil (PAHO)	6	

[a] No iodine-131 was detected.

Acknowledgement

Appreciation is expressed to the personnel of the following agencies who provide data for their milk surveilance networks:

Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiological Health Section
Division of Occupational and Radiological Health
Colorado Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Radiological and Occupational Health Section
Department of Health and Rehabilitative Services
State of Florida

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiation Control Section
Environmental Health Division
Kansas State Department of Health

Radiological Health Services
Division of Occupational Health
Michigan Department of Health

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Pollution Control
New York State Department of Environmental Conservation

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Radiation Control Section
Division of Health
Washington Department of Social and Health Services

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs reported in *Radiological Health Data and Reports* are as follows:

Program	Period reported	Issue
California Diet Study	July-December 1970	November 1971
Carbon-14 in Total Diet and Milk	January-June 1971	December 1971
Connecticut Standard Diet	January-December 1970	December 1971
Institutional Total Diet	April-June 1971	November 1971
Strontium-90 in Tri-City Diets	January-December 1970	November 1971

SECTION II. WATER

The Environmental Protection Agency and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*) set the limits for approval of a drinking water supply containing radium-226 and strontium-90 at 3 pCi/liter and 10 pCi/liter, respectively. Higher concentrations may be acceptable if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities reported in *Radiation Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Water sampling program	Period reported	Issue
California	January-December 1969	October 1971
Gross Radioactivity in Surface Waters of the United States	May 1971	January 1972
Interstate Carrier Drinking Water	1970	July 1971
Kansas	January-December 1970	December 1971
Minnesota	January-June 1970	November 1971
North Carolina	January-December 1967	May 1969
New York	July 1969-June 1970	September 1971
Radioactivity in Florida Waters	1969	January 1972
Radiostrontium in Tap Water, *HASL*	January-June 1970	April 1971
Tritium in Community Water Supplies	1969	December 1970
Tritium Surveillance System	April-June 1971	November 1971
Washington	July 1968-June 1969	February 1971

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(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Gross Radioactivity in Surface Waters of the United States June 1971

Office of Water Programs
U.S. Environmental Protection Agency

The monitoring of gross radioactivity in surface waters of the United States was initiated in 1957 as part of the Water Pollution Surveillance System (formerly National Water Quality Network) of the U.S. Public Health Service. Currently, the program is operated by the U.S. Environmental Protection Agency, Office of Water Programs. Regional offices of the Environmental Protection Agency are responsible for the collection of samples and the entering of the resulting data into the analytical storage and retrieval system. Radioactivity analyses are performed in the centralized radioactivity laboratories of the Office of Water Program (Cincinnati, Ohio).

The regular reporting of gross radioactivity data in *Radiological Health Data and Reports* was terminated with the publication of data for October 1968 (April 1969 issue). This activity was reinitiated as a monthly report series with the publication of data for January 1971 (September 1971 issue). The unpublished data for the time interval, November 1968 through December 1970, will be the subject of a future summary article.

Table 1 presents the gross alpha and beta results for samples collected from 31 rivers during June 1971. The analytical procedures used for determining gross alpha and beta radioactivity are described in the 13th Edition of *Standard Methods for the Examination of Water and Wastewater* (*1*). Results are reported for the date of counting and are not corrected to the date of collection. The sensitivity in counting is that defined by the National Bureau of Standards, Handbook 86 (*2*) and is calculated to be <0.2 pCi/liter for gross alpha radioactivity and <1 pCi/liter for gross beta radioactivity measurements.

REFERENCES

(*1*) AMERICAN PUBLIC HEALTH ASSOCIATION; AMERICAN WATER WORKS ASSOCIATION AND WATER POLLUTION CONTROL FEDERATION. Standard methods for the examination of water and wastewater, 13th edition, New York, N.Y. (1971).

(*2*) U.S. DEPARTMENT OF COMMERCE. Radioactivity, Recommendations of the International Commission on Radiological Units and Measurements (1962), NBS Handbook 86 (November 29, 1963).

Table 1. Gross radioactivity in U.S. surface waters, June 1971

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Allegheny River: Pittsburgh, Pa. (7.1 miles)[b]	[c]1	<0.2	<0.2	2	6
Pittsburgh, Pa. (0.5 miles)[b]	[c]1	<.2	<.2	2	7
Beaver River: New Brighton, Pa	[c]1	<.2	2	3	15
Big Sandy River: Wayne County, W. Va	[c]1	8	<.2	35	4
Big Sioux River: Sioux Falls, S. Dak	[c]1	1	10	4	30
Cheyenne River: Edgemont, S. Dak	[d]1	17	3	102	22
Clinch River: Kingston, Tenn	1	<.2	<.2	2	3
Cuyahoga River: Cleveland, Ohio	[c]1	<.2	2	7	39

See footnotes at end of table.

Table 1. Gross radioactivity in U.S. surface waters, June 1971—continued

River and station	Number of grab samples[a]	Gross alpha radioactivity (pCi/liter)		Gross beta radioactivity (pCi/liter)	
		Suspended solids	Dissolved solids	Suspended solids	Dissolved solids
Delaware River:					
Trenton, N.J.	1	<.2	<.2	2	4
Detroit River:					
Detroit, Mich.	[c]1	<.2	<.2	2	2
Great Lakes:					
Lake Erie, Buffalo, N.Y.	[c]1	<.2	<.2	3	11
Great Miami River:					
Eldean, Ohio	[d]1	<.2	3	4	14
Sellars Road, Ohio	[d]1	1	2	6	13
Fairfield, Ohio	[d]1	<.2	4	4	12
American Materials Bridge, Ohio	[d]1	1	1	8	17
Lost Bridge, Ohio	[d]1	2	3	13	29
Green River:					
Pottsville, Ky.	[c]1	1	<.2	4	6
Guyandotte River:					
Guyandotte, W. Va.	[c]1	3	<.2	9	5
Kanawha River:					
Winfield Dam, W. Va.	[c]1	2	2	4	4
Mason County, W. Va.	[c]1	1	<.2	3	3
Kentucky River:					
Lock and Dam No. 1, Ky.	[d]1	3	1	14	7
Licking River:					
Covington, Ky.	[d]1	1	<.2	4	8
Little Miami River:					
Cincinnati, Ohio	[d]1	3	1	14	15
Maumee River:					
Toledo, Ohio	[c]1	2	2	6	13
Mississippi River:					
Burlington, Iowa	[d]1	<.2	<.2	11	6
Missouri River:					
Yankton, S. Dak.	[c]1	<.2	4	2	20
Omaha, Nebr.	[c]1	4	5	22	30
St. Joseph, Mo.	[c]1	2	7	30	16
St. Louis, Mo.	[c]1	6	4	26	21
Monongahela River:					
Pittsburgh, Pa. (4.5 miles)[b]	[c]1	<.2	1	3	6
Pittsburgh, Pa. (0.8 miles)[b]	[c]1	1	<.2	2	8
Muskingum River:					
Lock and Dam No. 2, Ohio	[c]1	<.2	2	3	7
North Platte River:					
Henry, Nebr.	[c]1	1	12	2	30
Ohio River:					
South Height, Pa.	[c]1	<.2	<.2	2	7
Hancock, W. Va.	[c]1	<.2	<.2	1	7
Warwood, W. Va.	[c]1	<.2	1	2	8
Ironton, Ohio	[d]1	3	<.2	20	8
Greenup Dam, Ky.	[d]1	3	<.2	11	8
Portsmouth Ohio	[d]1	2	1	16	9
Cane Run, Ky.	[c]1	2	<.2	8	6
Maysville, Ky.	[d]1	2	<.2	6	7
Cincinnati, Ohio	6	<.3 (<.2—1)	<.2 (<.2—<.2)	4 (2—6)	6.3 (5—8)
Miami Fort, Ohio	[d]1	1	1	7	9
Anderson Ferry, Ohio	[d]1	1	1	7	7
Markland Dam, Ky.	[d]1	1	<.2	5	9
Madison, Ind.	[d]1	1	<.2	2	6
Louisville, Ky.	[c]1	1	<.2	8	6
Meldahl Dam, Ohio	[d]1	<.2	<.2	<1	8
Boyd County, Ky.	[c]1	1	1	3	6
Gallipolis, Ohio	[c]1	<.2	2	2	8
Kyger Creek, W. Va.	[c]1	<.2	3	2	8
Addison, Ohio	[c]1	1	2	2	6
Old Lock No. 19, W. Va.	[c]1	1	<.2	15	9
Evansville, Ind.	[c]1	2	1	9	6
Marietta, Ohio	[c]1	1	<.2	3	2
New Martinsville, W. Va.	[c]1	<.2	<.2	3	7
Platte River:					
Plattsmouth, Nebr.	[c]1	2	2	31	17
Roanoke River:					
John Kerr Dam, Va.	4	<.2 (<.2—<.2)	<.2 (<.2—<.2)	3 (<1—5)	4.5 (2—6)
St. Lawrence River:					
Massena, N.Y.	3	<.2 (<.2—<.2)	<.7 (<.2—1)	1.7 (1—2)	6 (3—8)
St. Mary's River:					
Sault Ste. Marie, Mich.	[c]1	<.2	<.2	1	3
Susquehanna River:					
Conowingo Dam, Md.	[c]1	1	3	2	6
Wabash River:					
New Harmony, Ind.	[c]1	1	2	7	12
Whitewater River:					
Suspension Bridge, Ohio	[d]1	1	1	10	13

[a] Where more than one sample is analyzed during the month, the minimum and maximum values are in parentheses.
[b] Distance from mouth of river.
[c] Indicates a composited sample for the third quarter ending in June 1971 of 1971 Water Year (Oct 1970–Sept 1971).
[d] Indicates single monthly grab samples.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Environmental Protection Agency, the Canadian Department of National Health and Welfare, the California Air Sampling Program, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiation Data and Reports.*

Network	Period	Issue
Fallout in the United States and other areas, *HASL*	January-December 1970	December 1971
Plutonium in Airborne Particulates	January-March 1971	November 1971
Surface Air Sampling Program, 80th Meridian Network, *HASL*	January-December 1968	April 1971
Mexican Air Monitoring Program	August-December 1970 and January 1971	October 1971

1. Radiation Alert Network October 1971

Division of Atmospheric Surveillance
Environmental Protection Agency

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 70 locations distributed throughout the country (figure 1). Most of these stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Environmental Protection Agency officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Air Quality Information Systems Branch, Division of Atmospheric Surveillance, EPA, Research Triangle Park, N.C. 27711. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during October 1971.

All field estimates reported were within normal limits for the reporting station.

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1971

Station location		Number of samples	Gross beta radioactivity (5-hour field estimate) (pCi/m³)			Number of samples	Total depth (mm)	Precipitation		
								Field estimation of deposition		
			Maximum	Minimum	Average [a]			Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	5	1	2	2	28	2	28	9
Alaska:	Anchorage	2	0	0	0	0				
	Attu Island	29	0	0	0	0				
	Fairbanks	14	1	0	0	7	30	7	30	11
	Juneau	0				0				
	Kodiak	0				0				
	Nome	0				0				
	Point Barrow	0				0				
Ariz:	Phoenix	9	11	1	4	0				
Ark:	Little Rock	8	1	0	0	0				
Calif:	Berkeley	19	1	0	0	0				
	Los Angeles	0				0				
C.Z:	Ancon	14	0	0	0	0				
Colo:	Denver	18	7	0	3	1	4	[b]		
Conn:	Hartford	18	3	0	1	2	28	2	28	0
Del:	Dover	16	1	0	0	0				
D.C:	Washington	21	2	0	0	0				
Fla:	Jacksonville	18	1	0	0	4	97	4	97	25
	Miami	17	0	0	0	8	134	8	134	0
Ga:	Atlanta	10	2	1	2	0				
Guam:	Agana	0				0				
Hawaii:	Honolulu	19	1	0	0	3	18	[b]		
Idaho:	Boise	19	6	1	2	3	22	3	22	0
Ill:	Springfield	14	5	0	2	0				
Ind:	Indianapolis	19	2	0	0	0				
Iowa:	Iowa City	20	4	0	2	2	27	2	27	0
Kans:	Topeka	20	4	1	2	7	62	7	62	2
Ky:	Frankfort	0				0				
La:	New Orleans	21	1	0	0	4	63	[b]		
Maine:	Augusta	15	2	0	1	2	81	2	81	0
Md:	Baltimore	19	2	0	0	3	30	3	30	0
Mass:	Lawrence	19	3	0	1	3	62	2	44	0
	Winchester	18	4	0	1	3	63	3	63	0
Mich:	Lansing	20	1	0	1	7	63	7	63	10
Minn:	Minneapolis	16	3	0	1	6	137	6	137	28
Miss:	Jackson	15	4	0	1	1	5	1	5	2
Mo:	Jefferson City	19	4	0	1	6	65	6	65	0
Mont:	Helena	17	3	0	1	3	16	2	11	0
Nebr:	Lincoln	9	8	2	4	1	30	1	30	13
Nev:	Las Vegas	18	3	1	1	0				
N.H:	Concord	0				0				
N.J:	Trenton	20	1	0	0	4	97	4	97	0
N. Mex:	Santa Fe	12	3	0	1	0				
N.Y:	Albany	17	1	0	0	0				
	Buffalo	15	2	0	1	0				
	New York City	0				0				
N.C:	Gastonia	15	10	1	3	1	8	[b]		
N. Dak:	Bismarck	18	3	0	1	1	52	1	52	0
Ohio:	Cincinnati	0				0				
	Columbus	3	2	1	1	0				
	Painesville	18	3	0	1	5	31	5	31	15
Okla:	Oklahoma City	0				0				
	Ponca City	18	5	0	2	6	75	5	50	3
Oreg:	Portland	20	1	0	0	9	72	9	72	3
Pa:	Harrisburg	12	2	0	0	0				
P.R:	San Juan	0				0				
R.I:	Providence	19	5	0	1	1	16	1	16	0
S.C:	Columbia	18	4	0	1	4	91	4	91	0
S. Dak:	Pierre	19	6	1	3	0				
Tenn:	Nashville	19	3	0	1	3	42	3	42	3
Tex:	Austin	5	2	0	1	1	11	[b]		
	El Paso	18	5	0	1	0				
Utah:	Salt Lake City	27	2	0	1	9	80	7	64	6
Vt:	Barre	19	7	0	2	4	56	4	56	4
Va:	Richmond	19	2	0	0	5	144	4	123	29
Wash:	Seattle	8	0	0	0	6	75	[b]		
	Spokane	17	2	0	1	0				
W. Va:	Charleston	18	3	0	1	3	29	3	29	5
Wisc:	Madison	20	2	0	1	5	25	5	25	1
Wyo:	Cheyenne	19	7	0	3	1	8	1	8	1
Network summary		961	11	0	1	146	62	4	54	5

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] This station is part of the tritium surveillance system. No gross beta measurements are done.

2. Canadian Air and Precipitation Monitoring Program,[1] October 1971

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for October 1971 are presented in table 2.

[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1971

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	7	0.1	0.1	0.1	74	1.9
Coral Harbour	7	.0	.0	.0	[a]	.3
Edmonton	7	.1	.0	.0	50	3.4
Ft. Churchill	7	.0	.0	.0	20	.9
Fredericton	7	.1	.0	.1	14	1.2
Goose Bay	7	.0	.0	.0	53	1.6
Halifax	6	.1	.1	.1	15	1.0
Inuvik	7	.0	.0	.0	15	1.2
Montreal	4	.1	.0	.1	44	1.7
Moosonee	7	.1	.1	.1	12	1.6
Ottawa	6	.1	.0	.0	50	2.2
Quebec	7	.0	.0	.0	35	2.6
Regina	6	.1	.0	.1	32	1.3
Resolute	7	.1	.0	.0	49	.5
St. John's, Nfld	6	.1	.1	.1	13	.6
Saskatoon	7	.1	.0	.1	35	.4
Sault Ste. Marie	7	.1	.0	.1	47	2.8
Thunder Bay	7	.1	.0	.1	25	3.5
Toronto	3	.2	.0	.1	29	1.5
Vancouver	7	.0	.0	.0	9	1.2
Whitehorse	7	.0	.0	.0	12	.3
Windsor	7	.1	.0	.1	17	.5
Winnipeg	7	.1	.0	.0	29	2.4
Yellowknife	6	.1	.0	.1	20	.7
Network summary	156	0.2	0.0	0.1	30	1.5

[a] Less than 0.1 inches precipitation.

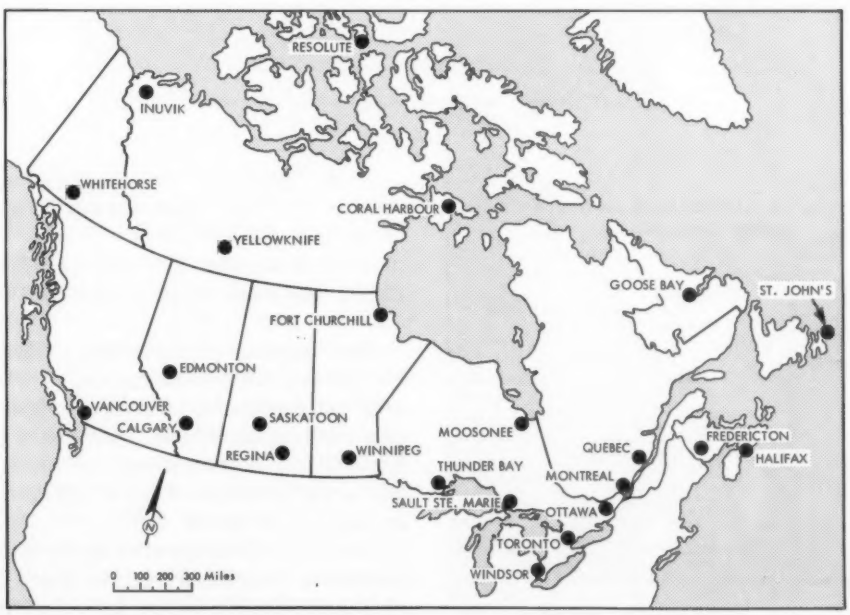

Figure 2. Canadian air and precipitation sampling stations

3. Pan American Air Sampling Program October 1971

Pan American Health Organization and U.S. Environmental Protection Agency

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Environmental Protection Agency (EPA) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 3. Analytical techniques were described in the March 1968 issue of *Radiological Health Data and Reports*. The October 1971 air monitoring results from the participating countries are given in table 3.

Figure 3. Pan American Air Sampling Program stations

Table 3. Summary of gross beta radioactivity in Pan American surface air, October 1971

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average [a]
Argentina:	Buenos Aires	0			
Bolivia:	La Paz	5	0.88	0.04	0.46
Chile:	Santiago	31	.90	.07	.41
Colombia:	Bogota	20	.09	.00	.03
Ecuador:	Cuenca	5	.11	.03	.08
	Guayaquil	14	1.30	.27	.74
	Quito	12	.23	.00	.04
Guyana:	Georgetown	13	.24	.00	.08
Jamaica:	Kingston	0			
Peru:	Lima	19	1.17	.17	.56
Venezuela:	Caracas	19	.54	.00	.06
West Indies:	Trinidad	15	.39	.01	.15
Pan American summary		153	1.30	0.00	0.27

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

4. California Air Sampling Program October 1971

Bureau of Radiological Health
California State Department of Public Health

The Bureau of Radiological Health of the California State Department of Public Health with the assistance of several cooperating agencies and organizations, operates a surveillance system for determining radioactivity in airborne particulates. The air sampling locations are shown in figure 4.

All air samples are sent to the Sanitation and Radiation Laboratory of the State Department of Public Health where they are analyzed for their radioactive content.

Figure 4. California air sampling program stations

Airborne particles are collected by a continuous sampling of air filtered through a 47 millimeter membrane filter, 0.8 micron pore size, using a Gast air pump of about 2 cubic-feet-per minute capacity, or 81.5 cubic meters per day. Air volumes are measured with a direct reading gas meter. Filters are replaced every 24 hours except on holidays and weekends. The filters are analyzed for gross alpha and beta radioactivity. Analyses are normally made 72 hours after the end of the collection period. The daily samples are then composited into a monthly sample. A gamma-scan and an analysis for strontium-89 and strontium-90 are made. Table 4 presents the monthly gross beta radioactivity in air for October 1971.

Table 4. Gross beta radioactivity in California air, October 1971

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Bakersfield	28	1.23	0.10	0.34
Barstow	31	1.08	.12	.39
Berkeley	31	.29	.04	.14
Colfax	31	.34	.07	.18
El Centro	29	2.63	.18	.63
Eureka	29	.26	.04	.10
Fresno	29	1.45	.05	.37
Los Angeles	30	.58	.11	.25
Redding	31	.39	.10	.15
Sacramento	29	.91	.06	.26
Salinas	29	2.05	.10	.36
San Bernardino	29	.73	.11	.23
San Diego	29	.54	.11	.22
Santa Rosa	31	1.59	.05	.30
Summary	416	2.63	0.04	0.28

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(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).
(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

Air Surveillance Network, July 1971

Western Environmental Research Laboratory
Environmental Protection Agency
Las Vegas, Nev.

The Air Surveillance Network, operated by the Western Environmental Research Laboratory (WERL), consists of 104 active and 18 standby sampling stations located in 21 western States (figures 1 and 2). The network is operated in support of nuclear testing conducted by the Atomic Energy Commission (AEC) at the Nevada Test Site (NTS), at the Nuclear Rocket Development Station which lies adjacent to the NTS, and at any other western testing sites designated by the AEC.[1]

Sampling

Twenty-four hour samples of airborne particulates are collected daily at each active station on 4-inch diameter, glass-fiber filters at a flow rate of about 350 m^3 of air per day. Samples may be collected for shorter periods to document specific radioactivity releases. Activated charcoal cartridges following the filters are used regularly for collection of radioiodines at 22 stations near the NTS, and charcoal cartridges can be added to all other stations by telephone request. Continuous gamma radioactivity rate recorders are also located at 32 stations. The stations are operated by State health department personnel and by private individuals on a contract basis. All samples are mailed to the WERL unless special retrieval is arranged at selected locations in support of known releases of radioactivity from the NTS.

Analysis

The particulate filters are counted 5 minutes for gross beta radioactivity as soon as they are received and at 5 and 12 days after collection. Samples are counted on gas-flow proportional counters calibrated over a range of beta energies from 0.1 to 1.8 MeV. A conservative efficiency value of 45 percent (corresponding to an average maximum beta energy of 0.5 MeV) is used for data conversion. Those filters with total gross beta radioactivities of 500 cpm or greater are gamma scanned on a 4- by 4-inch sodium iodide (thallium-activated) crystal connected to a 400-channel gamma spectrometer. Individual radionuclides are quantitated from spectrometer data by the use of a computer and a matrix technique. The 5- and 12-day beta counts are used to extrapolate gross beta concentrations to mid-collection time for reporting. Extrapolation is accomplished by computer programs and is routinely based on a $T^{-1.2}$ decay. For known releases of radioactivity the decay rate is determined experimentally and is used in the extrapolations.

All charcoal cartridges are counted 10 minutes with a gamma spectrometer. Data from

[1] The ASN is operated under a Memorandum of Understanding (No. AT(26–1)–539) with the Nevada Operations Office, U.S. Atomic Energy Commission.

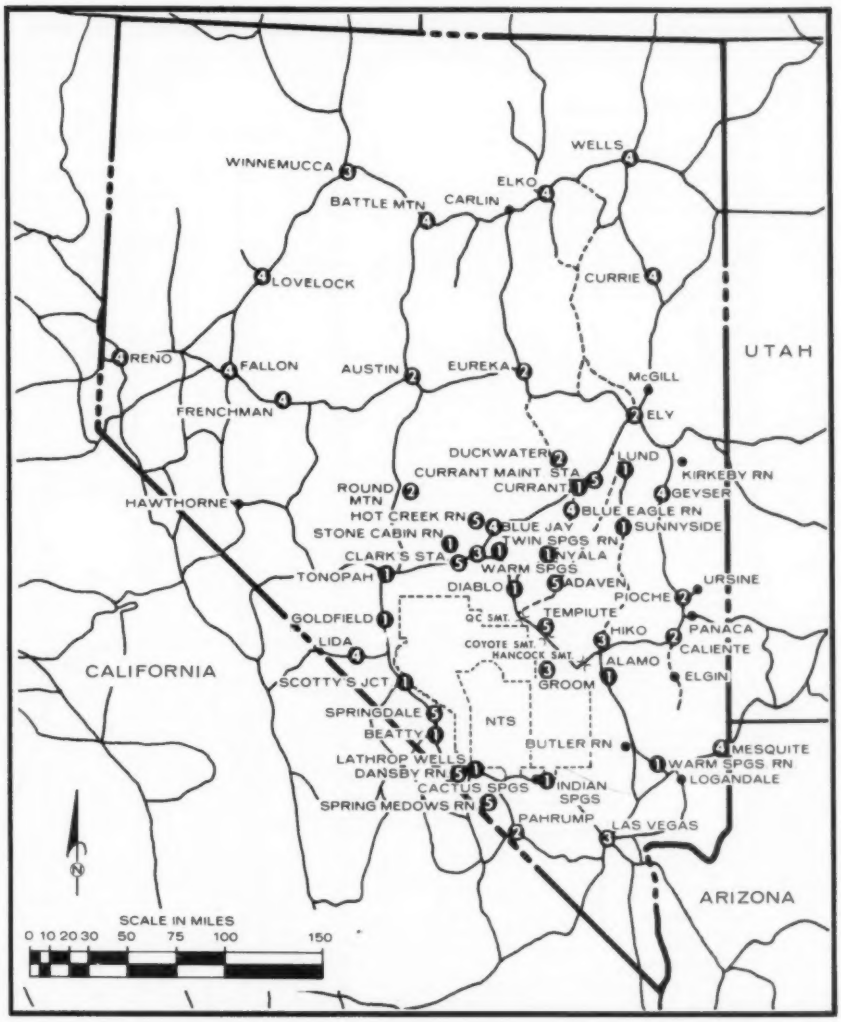

Figure 1. WERL Air Surveillance Network stations in Nevada

those cartridges having a net gross gamma count rate greater than 300 cpm are analyzed by a computer matrix to quantitate individual radionuclides.

Results

Table 1 presents the monthly average gross beta radiation in air particulates during July 1971. The minimum reporting concentration for gross beta radioactivity is 0.1 pCi/m³. For averaging purposes, individual concentrations which are below the minimum detectable concentration (0.06-0.07 pCi/m³) are assumed to be equal to the minimum detectable concentration. Averages less than the minimum reportable level (0.1 pCi/m³) are reported as <0.1 pCi/m³.

From gamma spectrometry results, zirconium-niobium-95, ruthenium-106, and cerium-144 from worldwide fallout were identified in varying combinations on filters collected in all States within the network except for Missouri, Arkansas, Oklahoma, Texas, and New Mexico. None of the standby stations were operated in

Table 1. Summary of gross beta radioactivity concentrations in air, July 1971

Station location		Number of samples	Concentrations[a] (pCi/m³)		
			Maximum	Minimum	Average
Ariz:	Kingman	31	2.1	0.2	0.5
	Phoenix	31	.8	<.1	.4
	Seligman	30	1.2	.2	.5
	Winslow	30	.6	.2	.4
Ark:	Little Rock	11	.9	<.1	.4
Calif:	Baker	30	1.7	.3	.7
	Barstow	31	1.5	.3	.7
	Bishop	31	1.8	.2	.7
	Death Valley Junction	26	1.7	<.1	.6
	Furnace Creek	29	1.9	<.1	.8
	Indio	29	1.3	.2	.5
	Lone Pine	30	1.6	<.1	.6
	Needles	26	1.8	.2	.6
	Ridgecrest	31	1.3	.2	.5
	Shoshone	31	1.4	.2	.5
Colo:	Denver	21	.9	.2	.5
	Durango	31	.8	.2	.4
Idaho:	Boise	31	1.6	.3	.8
	Idaho Falls	21	1.5	.3	.9
	Preston	31	1.8	.4	.9
	Twin Falls	31	1.3	.4	.8
Iowa:	Iowa City	20	1.3	<.1	.7
	Sioux City	27	1.1	.3	.7
Kans:	Dodge City	31	.5	.2	.3
La:	Lake Charles	20	.5	.1	.3
	Monroe	20	.9	<.1	.3
	New Orleans	17	.5	.1	.3
Minn:	Minneapolis	20	1.0	.2	.7
Mo:	Joplin	31	1.3	<.1	.6
	St. Joseph	31	1.2	.2	.6
	St. Louis	31	1.4	<.1	.6
Nebr:	North Platte	26	1.6	<.1	.7
Nev:	Alamo	31	1.5	.2	.6
	Austin	28	1.7	.2	.7
	Battle Mountain	31	1.6	.2	.8
	Beatty	31	1.8	.2	.7
	Blue Eagle Ranch (Currant)	30	1.5	<.1	.6
	Blue Jay	31	1.6	<.1	.6
	Caliente	31	1.6	<.1	.6
	Currant Ranch	31	1.3	<.1	.4
	Currie	31	1.7	.2	.7
	Diablo	31	1.8	.3	.7
	Duckwater	25	1.4	.1	.6
	Elko	31	1.4	.2	.6
	Ely	27	1.4	.2	.6
	Eureka	31	1.8	<.1	.7
	Fallini's Twin Springs Ranch	31	1.5	.2	.7
	Fallon	31	1.7	.1	.7
	Frenchman Station	31	2.0	<.1	.8
	Garrison	31	1.5	<.1	.7
	Geyser Maintenance Station	20	1.6	.2	.6
	Goldfield	30	1.5	.2	.6
	Groom Lake	25	1.4	.2	.6
	Hiko	31	1.5	.2	.6
	Indian Springs	31	1.5	.2	.6
	Las Vegas	21	1.4	<.1	.5
	Lathrop Wells	31	1.9	.3	.7
	Lida	30	1.5	<.1	.5
	Lovelock	31	1.8	.3	.8
	Lund	31	1.4	.2	.6
	Mesquite	31	1.7	.3	.6
	Nyala	32	1.6	.2	.7
	Pahrump	25	1.6	.2	.6
	Pioche	29	1.3	.1	.5
	Reno	31	1.8	.2	.7
	Round Mountain	30	1.6	<.1	.6
	Scotty's Junction	31	2.0	.2	.7
	Stone Cabin Ranch	32	1.4	<.1	.6
	Sunnyside	27	1.3	<.1	.5
	Tonopah	31	1.7	.2	.7
	Tonopah Test Range	28	1.8	<.1	.6
	Warm Springs Ranch	31	1.4	.2	.6
	Wells	31	1.9	.2	.8
	Winnemucca	31	1.4	.2	.7
N. Mex:	Albuquerque	25	.5	.1	.3
	Carlsbad	31	.6	.2	.3
Okla:	Muskogee	31	1.1	<.1	.5
Oreg:	Burns	31	1.7	.4	.8
	Medford	23	1.5	.2	.7
S. Dak:	Aberdeen	31	1.2	.3	.7
	Rapid City	31	1.7	.3	.9
Tex:	Abilene	28	.9	<.1	.4
	Amarillo	31	1.0	<.1	.5
	Austin	12	.5	<.1	.3
	Fort Worth	31	1.2	<.1	.4

See footnotes at end of table.

Table 1. Summary of gross beta radioactivity concentrations in air, July 1971 continued

Station location		Number of samples	Concentrations[a] (pCi/m³)		
			Maximum	Minimum	Average
Utah:	Bryce Canyon	21	1.4	<0.1	0.4
	Cedar City	27	1.3	.2	.5
	Delta	29	1.0	.2	.5
	Dugway	30	1.3	.2	.6
	Enterprise	31	1.4	.2	.5
	Logan	31	1.3	.2	.7
	Milford	29	1.8	<.1	.5
	Monticello	19	1.6	<.1	.3
	Parowan	31	1.7	<.1	.5
	Provo	23	1.2	.2	.6
	Roosevelt	31	1.5	.2	.6
	St. George	31	1.1	.2	.5
	Salt Lake City	30	1.5	.2	.8
	Wendover	31	1.6	.2	.8
Wash:	Seattle	21	1.6	.1	.4
	Spokane	17	1.3	.3	.8
Wyo:	Rock Springs	30	1.5	<.1	.8
	Worland	31	2.0	<.1	1.0

[a] Individual values less than the minimum detectable concentration (MDC) are set equal to the MDC for averaging. A monthly average less than the minimum reportable value of 0.1 pCi/m³ is reported as <0.1.

Figure 2. WERL Air Surveillance Network stations outside Nevada

Montana. The highest concentrations of these radionuclides, respectively, were 1.0 pCi/m^3 (Shoshone and Scotty's Junction), 1.8 pCi/m^3 (Furnace Creek and Lathrop Wells), and 1.6 pCi/m^3 (Shoshone). No radioactivity was identified on any of the charcoal cartridges.

Complete summaries of the daily station results are distributed to EPA regional offices and state health department offices. Copies of the daily gross beta results and gamma spectrometry results may be obtained from the WERL upon written request.

Surface Air Sampling Program—80th Meridian Network [1] January-December 1969

Health and Safety Laboratory
Atomic Energy Commission

The Health and Safety Laboratory began its Surface Air Sampling Program in January 1963, as a continuation of the 80th Meridian Program conducted by the U.S. Naval Research Laboratory. The objective of this program is to study the spatial and temporal distribution of nuclear weapons debris and lead in the surface air.

The basic network consists of a line of sites approximately along the 80th Meridian extending from about 76° N to 90° S latitudes (figure 1). Since 1963, a number of sites has been added to investigate the possible effects of longitude, elevation, and proximity to coastlines; and from late 1965 through March 1969, samplers were placed on four Atlantic Ocean weather ships to extend the surface air study over the marine environment.

Sampling and analytical procedures

Approximately 1,400 cubic meters of ambient air per day are drawn through an 8-inch diameter microsorban filter for the land stations. For the ocean stations, about 2,200 cubic meters of air per day are filtered by an 8- by 10-inch microsorban filter. Each filter is changed on the 1st, 8th, 15th, and 22nd of the month or more frequently if the filter becomes clogged with debris suspended in the air.

The filters are returned to HASL at the end of each month and under normal conditions, composited into monthly samples for analysis. Until late 1969, the composited sample was first gamma counted and then sent to a contractor laboratory for radiochemical analysis. In the current program, each sample is split into equal aliquots, one for gamma counting and spectrometry and the other for radiochemistry. Hence, half of each sample is now being kept and stored for possible future work.

Daily pump pressure drop and temperature readings are also submitted to HASL along with the samples for the purpose of computing the volume of sampled air.

Gamma analysis

The gamma activity of half of the monthly composites are obtained with a 8- by 4-inch sodium iodide (Tl) crystal as soon as possible after receipt of the samples. The integrated response between 100 KeV and 3.0 MeV is corrected by the average detection efficiency (35 percent) of the gamma photons present in fallout; and the total gamma activities are reported in units of photons per minute per 1,000 standard cubic meters.

[1] Summarized from "Fallout Program Quarterly Summary Report," HASL–239 (January 1, 1971); HASL–245 (October 1, 1971) available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22151.

Figure 1. HASL 80th Meridian Network sampling stations

Radiochemical analyses

The other halves of the monthly composites are sent to a contractor laboratory for radiochemical analyses.

There were no major weapon test series from the end of 1962 until May 1966. Consequently, only the longer-lived artificially produced radionuclides were present in the filters collected during this period and emphasis was given to the determination of manganese-54, iron-55, strontium-90, cadmium-109, cesium-137, cerium-144, plutonium-238, and plutonium-239. In samples collected after French or Chinese atmospheric weapons tests, additional short-lived nuclides were analyzed such as strontium-89, zirconium-95, and cerium-141.

The longer-lived fission products and plutonium-239 concentrations should describe the general distribution in surface air of all previous nuclear weapon debris which was transferred from the lower stratosphere to the troposphere during the collection period of this report. Other tracer nuclides can be associated with debris from a single detonation or series of detonations. Manganese-54 and iron-55 were produced in large quantities in the 1961 and 1962 test series. Cadmium-109 was generated by the U. S. high altitude test over Johnston Island on July 9, 1962. While plutonium-238 is present in low concentrations in nuclear weapons debris, about 17,000 curies of plutonium-238 were disseminated at high altitude in the stratosphere on April 21, 1964 during the reentry burnup of a SNAP-9A power source.

As the levels of any of the radionuclides drop to below practical detection limits they are eliminated from the radiochemical program; thus cadmium-109 was not analyzed after the end of 1967.

Most of the analyses of surface air samples were carried out from July 1967 through June 1969 by the Tracerlab Inc., Richmond, Calif., and from July 1969 through June 1970 by the Trapelo Division West, Richmond, Calif.

Table 1. Station location

Site		Latitude	Longitude (west)	Elevation (meters)
Greenland:	Thule	76° 36′N	68° 35′	259
Ontario:	Moosonee	51° 16′N	80° 30′	10
N.Y:	New York	40° 48′N	73° 58′	38
Va:	Sterling	38° 58′N	77° 25′	76
Fla:	Miami	25° 49′N	80° 17′	4
Bahamas:	Bimini	25° 46′N	79° 22′	3
Hawaii:	Mauna Loa	19° 28′N	155° 36′	3,401
P.R:	San Juan	18° 26′N	66° 00′	10
Panama:	Balboa	8° 58′N	79° 34′	23
Ecuador:	Guayaquil	2° 10′S	79° 52′	7
Peru:	Lima	12° 01′S	77° 08′	13
Boliva:	Chacaltaya	16° 21′S	68° 07′	5,220
Chile:	Antofagasta	23° 37′S	70° 16′	31
	Isle de Pasqua	27° 10′S	109° 26′	41
	Portillo	32° 50′S	70° 08′	2,850
	Santiago	33° 27′S	70° 42′	520
	Puerto Montt	41° 27′S	72° 57′	7
	Punta Arenas	53° 08′S	70° 53′	35
	Gabriel Gonzales Videla	64° 49′S	62° 52′	10

Results

The radioactivity concentrations in surface air during January-December 1969 are presented in tables 2 through 8. The sites are listed

Table 2. Strontium-89 concentrations in air, 1969 [a]

Site		Concentration[b] (dpm/1,000 standard m³ at midmonth)			
		Sept	Oct	Nov	Dec
Greenland:	Thule	9.20	8.70	—	—
Ontario:	Moosonee	16.7	8.66	4.57	2.50
N.Y:	New York City	12.6	10.6	4.61	3.57
Va:	Sterling	19.7	10.6	5.45	3.40
Fla:	Miami	4.95	8.37	7.68	7.96
Bahamas:	Bimini	8.81	11.2	9.90	15.2
Hawaii:	Mauna Loa	13.0	21.5	12.0	8.47
P.R:	San Juan	5.92	5.19	4.72	6.67
Panama:	Balboa	[c].39	[c]1.68	1.48	3.38
Ecuador:	Guayaquil	1.29	[c]1.71	2.68	[c]1.05
Peru:	Lima	[c]2.87	10.9	[c]4.12	[c]1.94
Bolivia:	Chacaltaya	5.16	[c]3.92	[c].85	1.71
Chile:	Antofagasta	—	[c]2.67	[d]	[c]5.80
	Santiago	5.09	9.33	[c]4.84	[d]
	Puerto Montt	[c]1.54	[c]1.86	111	—
	Punta Arenas	[c]1.49	[c]1.05	[c].62	[d]

[a] No data reported for January-August 1969.
[b] Errors are less than 20 percent except:
[c] Error between 20–100 percent.
[d] Error greater than 100 percent.
—, no data reported.

Table 3. Strontium-90 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	3.96	3.85	5.31	5.16	2.41	1.32	3.34	7.23	2.45	3.74	—	—
Ocean station:	Bravo	1.72	2.94	2.59	—	—	—	—	—	—	—	—	—
	Charlie	1.77	—	2.25	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	2.70	3.40	5.57	7.73	4.98	4.90	6.31	8.21	4.46	2.54	1.73	1.31
Ocean station:	Delta	2.02	2.50	12.02	—	—	—	—	—	—	—	—	—
N.Y:	New York City	2.62	2.85	3.43	5.22	5.36	6.37	—	.64	3.74	3.50	1.70	2.13
Va:	Sterling	3.23	—	4.80	5.43	9.39	8.66	7.58	7.63	5.16	3.11	2.00	1.80
Ocean station:	Echo	2.72	3.42	3.79	—	—	—	—	—	—	—	—	—
Fla:	Miami	4.63	—	5.03	4.51	1.91	2.51	4.53	4.04	1.38	2.69	2.93	3.42
Bahamas:	Bimini	3.13	3.38	3.75	6.59	5.30	2.02	5.40	5.17	2.36	2.17	3.62	5.95
Hawaii:	Mauna Loa	4.58	3.59	5.50	9.13	11.58	9.81	8.72	4.95	3.63	4.36	2.29	2.18
P.R:	San Juan	1.98	4.25	4.73	4.40	3.97	3.81	5.44	4.79	1.86	1.51	2.20	2.96
Panama:	Balboa	1.24	2.56	2.41	2.82	1.41	.46	1.43	.41	.19	[b].36	.45	1.25
Ecuador:	Guayaquil	1.73	1.29	.37	.26	.39	.49	.94	.32	.98	1.80	1.84	1.92
Peru:	Lima	4.75	5.20	2.79	2.16	.51	1.22	3.52	3.92	5.79	12.19	7.82	5.07
Bolivia:	Chacaltaya	1.31	1.47	.93	.96	2.33	3.21	6.41	5.31	3.11	3.51	[b].25	1.54
Chile:	Antofagasta	3.98	4.23	2.84	2.34	2.30	—	4.64	—	—	4.09	5.68	17.1
	Portillo	24.4	22.9	—	—	—	—	—	—	—	—	—	—
	Santiago	4.93	5.38	5.32	3.41	3.59	4.54	5.06	1.91	7.84	7.24	5.44	6.68
	Puerto Montt	4.12	2.95	4.13	3.02	2.47	2.16	2.61	2.87	2.63	2.99	2.33	—
	Punta Arenas	1.62	1.90	2.65	1.26	1.37	1.10	1.85	1.09	1.40	.97	1.10	1.20

[a] Errors are less than 20 percent except:
[b] error between 20 percent and 100 percent.
—, no data reported.

Table 4. Zirconium-95 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	5.86	10.8	17.7	—	22.8	17.5	49.5	—	29.1	24.5	—	—
Ocean station:	Bravo	4.02	9.67	10.7	—	—	—	—	—	—	—	—	—
	Charlie	[b]3.92	—	11.5	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	3.20	7.92	14.6	34.3	137	83.7	127	—	43.8	20.1	11.2	6.44
Ocean station:	Delta	5.08	9.93	70.5	—	—	—	—	—	—	—	—	—
N.Y:	New York City	5.68	—	19.4	53.8	—	128	—	—	59.3	29.8	11.6	10.7
Va:	Sterling	7.45	—	23.5	53.1	57.1	158	134.	—	54.3	24.9	13.5	8.84
Ocean station:	Echo	5.82	11.8	21.3	—	—	—	—	—	—	—	—	—
Fla:	Miami	15.3	—	46.8	79.9	108	68.6	102	67.2	19.3	25.0	23.3	22.9
Bahamas:	Bimini	12.5	27.8	56.4	139	115	73.5	130	71.8	26.3	24.9	29.1	35.6
Hawaii:	Mauna Loa	21.9	35.9	79.2	234	329	228	155	67.0	36.7	46.9	22.2	27.8
P.R:	San Juan	7.21	26.8	42.3	90.2	[b]78.0	91.0	109	57.8	18.1	14.0	12.7	17.6
Panama:	Balboa	6.99	18.8	24.6	49.7	33.3	11.0	20.9	5.62	1.71	4.82	3.16	8.45
Ecuador:	Guayaquil	53.2	27.8	6.96	4.87	3.67	4.08	7.18	3.31	4.92	4.77	4.42	4.14
Peru:	Lima	139	92.2	44.0	22.3	—	15.6	23.6	18.6	16.1	31.2	13.4	82.9
Bolivia:	Chacaltaya	35.2	26.1	13.4	12.1	26.3	25.4	44.0	29.8	15.1	9.92	[b].32	4.47
Chile:	Antofagasta	120	79.2	54.9	29.4	18.8	—	29.5	—	—	11.8	8.11	19.5
	Portillo	633	429	—	—	—	—	—	—	—	—	—	—
	Santiago	123	96.2	70.1	42.7	24.9	29.3	29.4	—	22.6	26.7	9.05	6.70
	Puerto Montt	81.6	61.5	55.6	32.9	21.8	13.2	13.1	11.8	8.53	6.20	4.30	—
	Punta Arenas	30.4	—	33.8	13.6	10.1	6.38	9.30	—	4.98	3.65	2.67	[c]

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
[c] Error greater than 100 percent.
—, no data reported.

according to latitude beginning with the most northern site at Thule, Greenland (table 1).

The concentrations are reported at the midpoint of the collection month for the plutonium isotopes and the fission products and on the following dates for the induced radionuclides, maganese-54 and iron-55, October 15, 1961; cadmium-109, July 9, 1962.

One standard deviation of the counting error for these data is always less than ±20 percent unless otherwise indicated.

Three quality control samples are submitted along with each monthly shipment of samples for analysis. A weighed aliquot of a standard solution of a nuclide to be analyzed is added to two of these filters and the third filter serves

Table 5. Cesium-137 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	5.72	5.86	8.13	—	3.87	2.03	5.14	—	3.46	4.91	—	—
Ocean station:	Bravo	2.60	4.71	4.14	—	—	—	—	—	—	—	—	—
	Charlie	3.03	—	3.69	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	4.73	5.20	8.75	10.6	8.71	8.60	13.0	—	6.77	3.53	2.74	2.27
Ocean station:	Delta	3.20	4.05	16.2	—	—	—	—	—	—	—	—	—
N.Y:	New York City	6.79	—	9.78	11.2	15.5	—	—	—	12.7	4.28	2.95	2.66
Va:	Sterling	5.40	—	9.12	8.68	14.3	14.2	11.8	—	7.77	4.86	3.33	2.84
Ocean station:	Echo	3.75	5.21	4.65	—	—	—	—	—	—	—	—	—
Fla:	Miami	7.70	—	13.2	8.27	7.58	5.34	8.57	7.52	3.29	5.79	5.36	7.51
Bahamas:	Bimini	7.00	9.85	9.78	11.9	8.75	5.01	11.2	8.30	3.23	4.01	6.42	9.33
Hawaii:	Mauna Loa	7.55	5.88	7.82	13.3	17.2	15.2	13.9	7.58	5.83	6.55	3.94	4.39
P.R:	San Juan	3.37	6.99	7.59	7.60	6.14	7.52	10.9	6.38	2.88	2.17	2.68	4.26
Panama:	Balboa	2.03	4.03	3.60	4.65	2.34	.78	2.20	.51	.33	.79	.66	1.86
Ecuador:	Guayaquil	3.16	2.41	.79	.60	.71	.76	1.66	.96	1.34	2.91	2.75	3.72
Peru:	Lima	7.65	8.02	4.36	3.01	—	2.65	6.15	5.04	7.57	16.1	10.7	7.11
Bolivia:	Chacaltaya	1.92	1.87	1.23	1.40	3.16	4.36	10.0	6.85	4.59	5.37	[b] .08	2.30
Chile:	Antofagasta	5.83	5.90	5.81	3.89	3.40	—	6.66	—	—	7.30	6.68	20.7
	Portillo	35.1	34.5	—	—	—	—	—	—	—	—	—	—
	Santiago	7.63	9.25	9.13	5.84	5.29	7.10	9.96	—	11.2	10.2	—	5.88
	Puerto Montt	4.48	4.77	5.34	4.37	3.86	3.01	3.52	3.84	3.12	3.91	2.62	—
	Punta Arenas	1.90	—	3.63	1.73	1.86	1.46	2.80	—	1.91	2.29	1.49	1.58

[a] Errors are less than 20 percent except:
[b] Error between 20 and 100 percent.
—, no data reported.

Table 6. Cerium-144 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth)											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	—	32.4	40.0	—	25.8	19.3	61.9	—	48.9	58.5	—	—
Ocean station:	Bravo	15.1	26.0	21.9	—	—	—	—	—	—	—	—	—
	Charlie	16.2	—	21.9	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	24.4	27.5	42.7	62.3	61.4	84.2	171	—	86.2	52.0	29.9	21.8
Ocean station:	Delta	20.7	26.7	99.3	—	—	—	—	—	—	—	—	—
N.Y:	New York City	27.8	—	43.6	63.7	109	103	—	—	140	63.0	31.4	32.2
Va:	Sterling	30.0	—	46.4	60.8	114	170	158	—	105	60.5	37.9	30.1
Ocean station:	Echo	22.6	29.0	32.9	—	—	—	—	—	—	—	—	—
Fla:	Miami	47.8	—	69.9	65.7	93.8	70.3	93.1	106	38.1	48.5	55.7	73.6
Bahamas:	Bimini	41.1	52.5	67.3	89.4	86.6	67.4	153	124	50.6	50.4	71.5	98.5
Hawaii:	Mauna Loa	42.3	36.5	55.7	155	229	204	181	102	72.3	76.7	41.8	46.3
P.R:	San Juan	18.3	38.1	48.5	65.1	67.4	91.3	124	95.0	36.3	23.5	—	43.2
Panama:	Balboa	13.4	25.9	25.1	37.0	26.1	9.67	26.2	8.80	3.55	6.98	6.01	18.0
Ecuador:	Guayaquil	51.0	32.0	9.0	7.19	8.21	9.3	20.0	15.2	16.6	27.8	23.3	36.3
Peru:	Lima	120	118	61.6	40.2	—	32.3	70.4	67.1	77.0	170	95.2	57.9
Bolivia:	Chacaltaya	28.9	28.6	17.0	16.4	39.1	52.0	103	79.0	55.3	51.8	.79	18.9
Chile:	Antofagasta	102	89.5	78.9	42.5	43.9	—	73.0	—	—	71.5	59.5	196
	Portillo	634	460	—	—	—	—	—	—	—	—	—	—
	Santiago	119	134	117	60.4	62.4	82.2	82.6	—	116	98.2	66.2	67.1
	Puerto Montt	66.3	69.9	72.9	56.3	45.8	31.8	25.2	43.8	38.1	40.0	21.9	—
	Punta Arenas	26.8	—	45.6	22.1	20.4	16.2	28.0	—	21.9	18.9	13.0	12.8

[a] Errors are less than 20 percent.
—, no data reported.

as a blank. The pattern of additions is varied for each nuclide so that different filters are blank for different nuclides.

All of the values reported by the contractor are corrected for a reagent blank, so that the blank values reported here reflect the contamination of the filter material both during manufacture and during handling at HASL and at the contractor laboratory.

Table 9 lists the results of the analyses of the blanks for each nuclide. In general, these data indicate low levels of contamination for most of the nuclides. The average plutonium-238 blank, which rose from 0.04 dpm in 1967 to 0.22

Table 7. Plutonium-238 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth) ×100											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	1.60	2.81	3.73	4.16	1.80	0.83	[b] 0.83	1.98	[b] 1.49	[c]	—	—
Ocean station:	Bravo	2.31	2.28	3.54	—	—	—	—	—	—	—	—	—
	Charlie	1.74	—	2.65	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	1.81	2.25	3.69	5.73	4.38	3.40	2.94	4.03	[b] 1.68	2.76	[b] 1.12	[b] 0.90
Ocean station:	Delta	2.09	1.33	6.61	—	—	—	—	—	—	—	—	—
N.Y:	New York City	3.51	2.98	4.52	7.81	6.31	5.67	—	3.57	2.55	1.46	.91	0.91
Va:	Sterling	4.04	—	4.07	7.66	[b] 9.22	4.19	[b] 4.59	2.48	[b] .89	1.31	[b] .72	[b] .78
Ocean station:	Echo	5.23	3.10	9.52	—	—	—	—	—	—	—	—	—
Fla:	Miami	3.12	—	4.39	4.23	4.17	[b] 1.44	[b] 1.96	2.19	[b] 1.50	1.09	1.92	[b] 1.03
Bahamas:	Bimini	2.79	3.86	4.71	5.94	3.04	[b] 1.15	[b] 1.67	1.41	[b] .68	[b] .37	[b] .93	[b] 2.08
Hawaii:	Mauna Loa	2.94	2.82	3.42	5.58	5.95	4.14	2.57	1.76	[b] 1.55	1.53	2.23	[b] 3.31
P.R:	San Juan	1.41	3.33	4.82	3.00	1.92	3.22	3.38	[b] 1.72	[b] .47	[b] .73	[b] .50	[b] 1.28
Panama:	Balboa	[b] .69	2.12	.84	2.18	[b] 1.67	[b] .26	.81	[b] 0.71	[b] .72	[b] .63	[b] .19	[b] .32
Ecuador:	Guayaquil	2.44	1.66	.75	.67	[b] .41	[b] .48	[b] 1.28	[c]	[b] 1.06	[b] .93	[b] 1.76	2.01
Peru:	Lima	5.47	5.81	3.20	2.08	1.21	[b] 1.86	3.34	[b] 2.99	3.42	9.16	4.89	3.19
Bolivia:	Chacaltaya	[b] 1.67	1.67	1.11	.99	2.66	3.01	3.38	3.44	[b] 1.24	2.76	[c]	[b] 1.62
Chile:	Antofagasta	[b] 4.10	3.31	3.86	2.84	1.87	—	[b] 3.31	—	—	3.67	3.99	9.43
	Portillo	24.3	23.2	—	—	—	—	—	—	—	—	—	—
	Santiago	[b] 5.72	6.85	6.45	4.54	3.56	11.8	5.65	1.22	[b] 4.71	6.11	—	4.16
	Puerto Montt	4.46	3.31	3.65	3.46	2.45	1.75	1.91	2.56	[b] 1.32	2.19	[b] 1.00	—
	Punta Arenas	[b] 1.78	—	2.99	1.50	1.29	1.06	1.50	.84	3.49	[b] .86	[b] .93	[b] .96

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
[c] Error greater than 100 percent.
—, no data reported.

Table 8. Plutonium-239 concentrations in air, 1969 [a]

Site		Concentration (dpm/1,000 standard m³ at midmonth) ×100											
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Greenland:	Thule	9.02	9.17	12.7	12.0	5.32	3.16	7.26	14.1	4.96	7.17	—	—
Ocean station:	Bravo	4.05	6.96	7.21	—	—	—	—	—	—	—	—	—
	Charlie	4.90	—	6.77	—	—	—	—	—	—	—	—	—
Ontario:	Moosonee	6.97	7.65	13.5	18.2	13.6	11.7	15.7	18.6	8.82	19.0	3.18	2.69
Ocean station:	Delta	5.62	5.80	31.0	—	—	—	—	—	—	—	—	—
N.Y:	New York City	12.0	7.94	15.6	20.3	21.2	19.2	—	22.2	14.0	7.00	3.76	4.40
Va:	Sterling	8.28	—	13.7	15.1	22.7	17.1	[b] 14.5	16.0	10.2	6.48	3.80	4.07
Ocean station:	Echo	5.36	7.81	10.2	—	—	—	—	—	—	—	—	—
Fla:	Miami	14.1	—	20.0	13.7	13.4	6.43	11.5	9.88	3.68	5.30	6.91	9.85
Bahamas:	Bimini	11.7	13.9	16.6	15.0	12.0	7.30	16.0	11.6	4.94	6.00	8.03	17.1
Hawaii:	Mauna Loa	11.5	8.92	11.5	21.7	24.5	20.1	16.7	10.0	6.18	8.15	3.75	7.47
P.R:	San Juan	5.07	9.50	12.4	9.49	7.20	9.75	13.1	16.5	3.59	2.28	3.53	5.38
Panama:	Balboa	[b] 2.85	7.41	4.72	5.76	3.07	.94	2.13	6.06	[b] .36	[b] .71	[b] .57	2.87
Ecuador:	Guayaquil	1.64	[b] .79	.60	.56	[b] .49	.77	[b] .68	[b] 1.50	[b] 2.78	2.48	2.73	4.77
Peru:	Lima	4.06	3.41	2.40	1.78	1.57	[b] 1.91	5.82	[b] 6.41	6.78	14.5	11.1	6.35
Bolivia:	Chacaltaya	[b] .98	1.03	.70	.99	2.22	4.61	7.53	7.45	5.13	4.66	[b] .21	2.63
Chile:	Antofagasta	[b] 2.44	2.82	2.73	2.22	2.28	—	6.50	—	—	6.80	6.53	20.3
	Portillo	16.9	16.1	—	—	—	—	—	—	—	—	—	—
	Santiago	[b] 4.18	4.28	4.38	3.89	3.81	6.02	6.60	2.30	12.2	9.82	—	8.81
	Puerto Montt	[b] 2.54	2.33	2.73	2.37	2.48	1.92	2.73	3.63	3.19	3.54	2.20	—
	Punta Arenas	[b] .71	—	1.53	[b] .89	1.06	0.97	1.74	1.14	4.38	2.01	1.80	[b] .80

[a] Errors are less than 20 percent except:
[b] Error between 20–100 percent.
—, no data reported.

Table 9. Quality control results on blank samples, 1969 (values in dpm/sample ± standard deviation)

Date (1969)	Strontium-89	Strontium-90	Zirconium-95	Cesium-137	Cerium-144	Plutonium-238	Plutonium-239
January	NA	2.6 ±1.7	5.9 ±6.9	0.4 ±0.4	2.0 ±1.9	0.5 ±0.06	0.02 ±0.02
February	19 ±137	2.5 ± .6	58.9 ±69	.9 ± .6	1.7 ±4.4	.2 ± .04	.06 ± .04
March	87 ±114	1.6 ±1.3	0 ±45	.4 ± .5	4.5 ±4.2	1.20 ±0.1	.04 ± .04
April	NA	1.1 ± .5	16.8 ±12.7	1.3 ±7.9	17.0 ±3.0	.05 ± .05	.0 ± .02
May	NA	.47 ± .20	4.3 ± 8.0	1.3 ±1.0	1.2 ±2.4	.15 ± .06	.0 ± .04
June	NA	NA	7.6 ± 5.5	.9 ± .6	47.0 ±4.7	.11 ± .07	.01 ± .04
July	3.6 ± 5.7	.2 ± .8	18.3 ± 9.0	.4 ± .7	1.2 ± .5	.3 ± .05	.0 ± .01
August	28 ± 39	.0 ± .3	1.5 ± 8.4	.5 ± .4	2.3 ±3.1	.01 ± .02	.0 ± .01
September	.0 ± 8.6	.9 ±1.3	1.5 ± 6.4	.3 ±1.3	2.4 ±2.0	.0 ± .02	.0 ± .02
October	1.0 ± 3.7	.4 ± .3	9.1 ± 9.5	.9 ±2.8	3.2 ±2.6	.05 ± .04	.01 ± .01
November	.0 ± 3.5	.1 ± .7	3.8 ± 5.9	.3 ± .3	2.7 ±2.0	.03 ± .04	.04 ± .03
December	.5 ± 2.6	.7 ± .3	3.1 ± 5.3	.8 ± .8	.8 ±2.1	.03 ± .06	.40 ± .04

NA, no analysis.

Table 10. Quality control results on standard samples, 1969 (average values in percent deviation)

Date (1969)	Strontium-89	Strontium-90	Zirconium-95	Cesium-137	Cerium-144	Plutonium-238	Plutonium-239
January	NA	11.6	−21.8	3.5	13.7	−2.5	−42.9
February	33.9	−8.0	−14.5	− .8	13.9	19.0	11.7
March	7.5	−8.5	−19.3	−1.9	14.0	17.4	−19.9
April	NA	.0	7.0	5.0	−4.9	−2.0	−6.5
May	NA	−2.0	−9.9	5.8	5.4	−5.3	−6.1
June	NA	1.2	−7.0	24.1	4.5	−2.9	−7.8
July	−12.1	−14.0	−7.9	− .7	3.4	.7	17.7
August	−1.0	−6.0	39.0	−3.1	5.2	66.0	60.0
September	−3.5	4.8	−5.6	−4.1	7.7	33.4	37.0
October	−14.0	−10.8	−8.8	−3.6	3.6	5.4	1.6
November	.4	−2.1	−11.5	.8	3.0	5.3	3.3
December	−7.6	−6.8	−12.6	4.6	3.3	1.5	−2.1

NA, no analysis.

dpm in 1968, remained at this level in 1969, however, this was mainly because of the anomolously high value in March 1969. Because the amount of plutonium-239 found in surface air samples is frequently in the range of 1 dpm, this blank may represent a significant fraction of the total activity.

The results of analyses on standard samples are shown in table 10. These data are indicative of the accuracy of the radiochemical analyses. The values shown are the average percent deviations between the added activities and the results reported by the contractor. Although most of the results are satisfactory, the August and September 1969 deviations for both plutonium isotopes are extremely high. The very low blank values during these months indicate no plutonium contamination. The plutonium-238 to plutonium-239 and plutonium-239 to strontium-90 ratios for actual samples collected during these months are all reasonable and therefore there is no reason to suspect that they are in error, however, no explanation can be offered to account for these poor quality control results.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-December 1968	April 1971

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Strontium-90 in Human Vertebrae, 1968, 1969, and 1970 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since 1960, measurements of the strontium-90 content of foods and estimates of the daily intake of strontium-90 at New York City, Chicago, and San Francisco have been made by the Health and Safety Laboratory (HASL). Since 1961, measurements of the strontium-90 content of human vertebrae obtained for HASL by cooperating pathologists at the three cities have also been made. In 1968, sampling in Chicago was discontinued. Data obtained from these programs have been used to construct models that attempt to explain the variation of strontium-90 concentrations in bone with age and time. The main purpose of the work is to provide estimates of the radiation dose to man that has resulted from the fallout from nuclear weapons tests. In attempting to construct the models it has become apparent that there are serious gaps in our knowledge of mineral metabolism, especially that of children. The survey data have therefore been used, at times, to gain some insight into the metabolism of strontium by children. This approach is very difficult because of the small numbers of specimens that are available and the absence of an exact knowledge of the diet of the children from whom specimens were obtained. Because it is unlikely that much direct experimental data from tracer studies on children will ever be available, we will be forced to rely on the indirect evidence from survey results to construct our models.

A listing of the results obtained as part of this program through 1964, along with an interpretation of the data was given earlier (*1*). Results of the analyses of samples obtained in 1965 and 1966 were previously reported (*2,3*).

The average strontium-90 concentrations observed in 1968 appeared to be only slightly less than those observed in 1967. As in previous years, the strontium-90 to calcium ratios of vertebrae from San Francisco were lower than those from New York City, reflecting the lower strontium-90 content of the diet in San Francisco as compared to New York City. Results of the analyses of samples obtained during 1968 are summarized in table 1.

Table 1. Strontium-90 to calcium ratios in human vertebrae, 1968

Age	(pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
<1 month	—	[a] 0.68 (20)
1 month–1 year	3.25 (8)	1.84
1– 2	3.56 (4)	1.69 (5)
2– 3	—	—
3– 4	—	—
4– 5	4.45 (3)	1.46
5– 6	3.97 (3)	—
6– 7	—	1.42 (4)
7– 8	2.72 (3)	—
8– 9	3.64	.85
9–10	1.97 (2)	1.57
10–11	2.89 (2)	—
11–12	—	1.30 (2)
12–13	—	—
13–14	3.16 (2)	—
14–15	3.76	1.76 (2)
15–16	3.36 (5)	.85
16–17	3.01 (6)	—
17–18	3.03 (4)	—
18–19	3.19 (5)	1.23 (2)
19–20	2.31 (5)	—
20–30	1.97 (8)	1.58 (2)
30–40	1.70 (5)	1.52 (3)
40–60	1.94 (5)	1.17 (8)
>60	1.83 (15)	1.13 (10)

[a] Number in parentheses indicates number of specimens.

[1] Summarized from Fallout Quarterly Summary Reports, HASL–210 (July 1, 1969); HASL–227 (July 1, 1970) and HASL–243 (July 1, 1971).

The 1969 bone strontium-90 levels for New York City were about two times higher than those for San Francisco, reflecting the higher levels of strontium-90 in the New York City diet. In general, the bone levels for all ages in New York City in 1969 were about 25 percent lower than in 1968. The San Francisco data, on the other hand, indicate no obvious change between 1968 and 1969. Children's bone continued to show strontium-90 levels about one and one-half to two times higher than adults in both cities. Results of the analyses of samples obtained during 1969 are summarized in table 2.

Table 2. Strontium-90 to calcium ratios in human vertebrae, 1969

Age	(pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
0– 1 month		0.6 (61)
1– 2		1.0 (6)
2– 5		1.7 (6)
6– 1 year	[a] 2.6 (23)	2.2 (7)
0– 1 year		
1– 2	2.7	1.6 (5)
2– 3	3.2 (2)	1.2 (5)
3– 4	3.6	1.5 (4)
4– 5	2.8 (2)	1.0 (2)
5– 6	2.4	1.8 (3)
6– 7	2.2 (2)	1.1 (2)
7– 8	—	—
8– 9	1.7	1.5 (3)
9–10	2.3 (3)	—
10–11	—	—
11–12	2.4	1.1 (2)
12–13	2.8	1.1
13–14	2.7 (4)	—
14–15	2.9 (3)	1.4 (2)
15–16	2.4 (2)	1.3
16–17	3.2 (2)	1.1
17–18	2.2 (8)	1.4 (4)
18–19	2.0	.8 (2)
19–20	—	—
20–30	1.7 (10)	1.0 (11)
30–40	1.4 (6)	.8 (13)
40–50	—	.9 (16)
50–60	1.9 (4)	.9 (25)
60–70	2.0 (5)	1.0 (15)
70–90	1.7 (4)	.8 (4)

[a] Number in parenthesis indicates number of samples (HASL–227).

The average values and standard deviations for New York and San Francisco adult vertebrae in 1970 were 1.55± 0.36 pCi ^{90}Sr/g Ca and 0.86 ± 0.30 pCi ^{90}Sr/g Ca, respectively. These values represent decreases of 13 percent in New York City and 8 percent in San Francisco from the average values of the previous year.

The strontium-90 to calcium ratios for children showed more variation than the adult values and generally higher values were obtained for children than adults. The highest values in both cities were for infants between the age of 4 months and 2 years. Results of the analyses of samples obtained during 1970 are summarized in table 3.

Table 3. Strontium-90 to calcium ratios in human vertebrae, 1970

Age	(pCi ^{90}Sr/g Ca)	
	New York City	San Francisco
0– 1 month		0.72 (58)
1– 2		.89 (6)
2– 3		1.73 (4)
4– 9		2.14 (6)
0– 9	[a] 2.47 (12)	
1– 2 year	2.77	1.71 (5)
2– 3	—	.95
3– 4	2.35	1.05 (3)
4– 5	—	.85
5– 6	1.87	—
6– 7	—	—
7– 8	—	.86
8– 9	—	—
9–10	1.85	1.19
10–11	—	1.33
11–12	—	1.16
12–13	1.94	1.22
13–14	2.47	1.60 (2)
14–15	1.89 (2)	.68
15–16	—	.66
16–17	1.38	.47
17–18	2.27 (3)	—
18–19	2.72 (4)	1.55 (2)
19–20	1.84 (6)	1.24 (2)
20–30	1.58 (13)	.96 (4)
30–40	1.44 (6)	.95 (7)
40–50	1.36 (5)	.80 (9)
50–60	1.57 (5)	.78 (16)
60–70	1.49 (10)	1.09 (9)
70–80	1.82 (9)	.89
80–90	1.41 (4)	—

[a] Number in parenthesis indicates number of samples.

Bone model

The model previously used by Rivera (*1*) to correlate the strontium-90 concentrations in diet and bone is described by the equation:

$$Ca_n X_n = Ca_{n-1}(1-F) X_{n-1} + Ca_{n-1}(F+R-1) K Z_{n-1}$$

where

Ca_n = Calcium content of the skeleton in the year n,

X_n = Strontium-90/calcium ratio in bone in the year n,

$R = Ca_n / Ca_{n-1}$

Z_{n-1} = average strontium-90 to calcium ratio in the diet, usually taken from midyear of the year n-1 to midyear of the year n. The X_{n-1} should contain correction for radioactive decay. The parameters F and K are determined by fitting the equation to the observed survey data. The factor F describes the bone turnover rate, or perhaps more appropriately, the effective strontium removal rate during the period n-1 to n. K is the bone-diet observed ratio.

The model is admittedly quite simple, in that only a single exponential removal rate of strontium from bone is assumed, even though this rate is allowed to vary with age. Undoubtedly, several processes of removal are proceeding with variable rates in various types of bone and at various locations within bone and on the surfaces. The model also assumes no reutilization of dissolved bone minerals. Thus, because of these simplifications in the model, some reservation must be made in assigning physiological significance to the parameters derived. The model, however, provides a useful empirical relation for describing the bone levels measured over the past years and for making short term predictions of future levels.

Rivera has previously applied multiple linear regression analysis to the New York City data for the periods, 1961–1965 (*1*) and 1961–1968 (*4*) to obtain estimates of the factors F and K. The data through 1970 and also the data from San Francisco have now been included in the analysis. The San Francisco data are comparable to the New York data, but the lower levels of strontium-90 concentrations in diet and bone provide a different situation from New York. Compromises are needed in the selection of the parameters to fit both the New York and San Francisco data, but more generally applicable results are obtained.

Regression results

The period through 1965 was a time of generally increasing concentrations of strontium-90 in bone. The New York data for this period were adequately fit by assuming a bone turnover rate of 72 percent per year for age 0–1 year, decreasing to about 20 percent per year at age 4–5 years. The turnover rate increased between 6–12 years and again during the late teenage years. For adult bone, an annual turnover rate of 8 percent and an observed ratio of 0.25 were assumed.

Since 1965, the bone levels have been decreasing at relatively rapid rates, more rapidly than would be inferred from the turnover rates derived for the periods of increasing bone levels. The turnover rates derived from the 1961–1968 and the 1961–1970 New York data are little different from one another, but are generally higher than previously determined. The survey data for all ages can be adequately fit by using these most recently derived values for the turnover rates and observed ratios.

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(*3*) RIVERA, J. Strontium-90 in human vertebrae-1966 results, HASL–182, p. I–10. U.S. Atomic Energy Commission (July 1967).
(*4*) RIVERA, J. Stronium-90 in human vertebrae-results for 1968, HASL–210. U.S Atomic Energy Commission (July 1969).

Offsite Surveillance Around the Nevada Test Site January-June 1966 [1]

Western Environmental Research Laboratory,[2] EPA, and Nevada Operations Office, AEC

Under a Memorandum of Understanding with the U.S. Atomic Energy Commission, the Western Environmental Research Laboratory (WERL), formerly the Southwestern Radiological Health Laboratory, conducted its continuing program of radiological surveillance, including monitoring and environmental sampling, in the public areas surrounding the Nevada Test Site (NTS) from January through June 1966. During this period, 29 announced underground nuclear tests were conducted at the NTS and nine Experimental Plans of the NRX-A4/EST and NRS-A5 nuclear rocket engine series were conducted at the Nuclear Rocket Development Station (NRDS), a part of the NTS complex.

Operational procedures

Comprehensive ground monitoring capabilities were maintained throughout the period. Mobile ground monitoring teams were positioned in offsite areas prior to each event. Each monitor was equipped with an Eberline E-500B survey meter, a Baird-Atomic Model NE-148A Scintillator, and Victoreen Radector, Model No. AGB-50B-Sr. Eberline RM-11 gamma-rate recorders were also available to document cloud passage at fixed ground locations. An Air Force U-3A aircraft with two WERL monitors was used for tracking airborne radioactivity to aid in the positioning of ground monitors. Two WERL aircraft were utilized as necessary for cloud sampling by cryogenic, electrostatic precipitator, and mass air sampling techniques.

The WERL Air Surveillance Network (ASN) consisted of 106 stations operating in every State west of the Mississippi River except Montana and North Dakota. The air sampler used was a Gelman "Tempest" which was equipped to use a 4-inch-diameter Whatman 541 filter paper and MSA charcoal cartridge.

In addition to air sampling, milk, water and vegetation samples were collected and analyzed. The routine milk sampling program was continued throughout the 6-month period, collecting 135 samples from both commercial dairies and private producers. Three hundred and fifty-eight water samples were collected from 76 sources of both potable and nonpotable supplies. Vegetation samples were collected after the nine releases of radioactivity to delineate any fallout pattern.

Approximately 150 residents in the offsite area wore film badge dosimeters during this period and 1,900 station badges were also distributed among the dosimetry station network. The DuPont type 545 film in the badge has a 30 mR lower limit of detection. Three EG&G Model TL-12 thermoluminescent dosimeters (TLD's) were used at each of 20 dosimetry stations.

A WERL medical officer was available to investigate cases of medical nature which might have occurred as a result of the nuclear testing. Similarly, a WERL veterinarian was available to conduct wildlife or domestic livestock investigations.

Analytical procedures

Samples were returned to the WERL in Las Vegas for radiological analysis. Air sample particulate filters were counted for beta radioactivity in a Beckman Widebeta low-background, proportional counter system. Selected particulate filters, all charcoal cartridges, and water and milk samples were analyzed for gamma-emitting isotopes; a 4- by 4-inch NaI (Tl) crystal coupled to a TMC Model 404C gamma pulse height analyzer was used. The lower

[1] This article is a summary of report No. SWRHL–37r, Off-Site Surveillance Activities of the Southwestern Radiological Health Laboratory from January through June 1966.

[2] Formerly part of U.S. Department of Health, Education, and Welfare, Public Health Service, Bureau of Radiological Health.

Table 1. Five highest air sampling results in off-Nevada Test Site areas January-June 1966

Date and time (Pdt) (on/off)	Location	Gross beta radioactivity (pCi/m³)	Radionuclide analysis (pCi/m³)	
			Iodine-131	Iodine-133
April 25 1413/1700	6.5 miles W of Hancock Summit	50,000	3,500 (P)[a] 150 (C)[b]	4,100 (P) 500 (C)
April 25 1400/1535	18 miles NE of Groom Lake	45,000	5,100 (P) 290 (C)	12,000 (P) 880 (C)
April 25 1435/1745	Hancock Summit	34,000	2,600 (P) 170 (C)	3,000 (P) 660 (C)
April 25 1430/1755	Ash Springs, Nev.	25,000	5,300 (P) 130 (C)	5,600 (P) 290 (C)
April 25 1430/1810	Hiko Crystal Springs	21,000	1,600 (P) 400 (C)	1,900 (P) 800 (C)

[a] P—Whatman-541 particulate filter.
[b] C—MSA charcoal cartridge, secondary to particulate filter, for collection of radioactive gases, primarily iodine.

limit of detection for gamma emitters in milk samples was 20 pCi/liter at the time of count. Gamma spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight radionuclides. Analyses for strontium-89 and strontium-90 were performed on selected samples.

Results

Three underground tests released radioactivity which was detected in offsite areas. These were the Red Hot Event on March 5, the Pin Stripe Event on April 25, and the Double Play Event on June 15. In addition, effluent was released to the offsite area during execution of Experimental Plans IIB, III, IV, and IVA of the NRX–A4/EST reactor test series, conducted on February 3, March 3, 16, and 25, respectively, and Experimental Plans III and IV of the NRX–A5, conducted on June 8 and 23. The highest levels of radioactivity measured offsite during this period are shown in tables 1 through 4. The highest ground monitoring reading at a populated area was 1.5 mR/h taken at Hiko at 1600 hours Pdt April 25, following the Pin Stripe Event. Pin Stripe also contributed the highest results found in air samples, milk samples, and potable water. There were no positive exposures on personnel film badges during this 6-month period.

A special innovation was introduced during this period to keep radioiodine levels in milk as low as possible. In regard to the ranches and dairies listed in table 2, all milk produced by family cows at the Davis, Donahue, and Sharp Ranches was taken for sampling purposes.

Table 2. Five highest radioiodine levels in milk samples in off-Nevada Test Site areas, January-June 1966

Date	Location	Iodine-131 concentration (pCi/liter)
April 27	Schofield Dairy, Hiko, Nev.	4,800
April 27	Davis Ranch, Hiko, Nev.	3,500
April 28	Sharp Ranch, Alamo, Nev.	2,100
April 28	L. Lee Dairy, Alamo, Nev.	1,400
April 28	Donahue Ranch, Ursine, Nev.	1,100

Uncontaminated milk and dairy products were substituted in lieu of cash payments. At the Schofield Dairy, stored hay from Utah was purchased and substituted for the green chop being fed at that time. Milk from the Lee Dairy and the Schofield Dairy was diluted with uncontaminated milk from dairies outside the affected areas. The substitution of dry hay kept radioiodine levels low and also provided experimental data for future planning purposes.

Table 3. Five highest potable water sample results in off-Nevada Test Site areas, January–June 1966

Location	Collection date	Iodine-131 concentration (pCi/liter)
Hiko, Davis Ranch	April 26	3,860
Ursine, McCrosky Ranch	May 2	360
Panaca, K. Lee Ranch	May 3	140
Ursine, Lytle Ranch	May 2	140
Caliente, Oxborrow Ranch	May 3	120

During the Pin Stripe Event, the WERL-designed thyroid dose assessment trailer was used for the first time under actual field conditions. Equipped with a 5- by 2-inch NaI crystal detector, a multichannel analyzer and proper shadow shielding, the trailer along with its pickup truck and generator constitutes a completely self-contained unit capable of determining actual thyroid dose in the field. Measurements were taken in locations determined from aerial surveillance and milk sampling data. Table 4 shows the results of total measurements taken.

Table 4. Number of people within a given range of computed thyroid dose, Pin Stripe Event

Location	Background	Background-50 mrad	50–150 mrad	150–300 mrad	Total
Alamo	10	17	6	0	33
Hiko	5	19	8	2	34
Ursine	4	1	0	0	5
Pioche	1	0	0	0	1
Panaca	5	0	0	0	5
Total	25	37	14	2	[a] 78

[a] Includes 37 male children and 33 female children.

Calculations were made on the basis of an inhaled dose after cloud passage. Although results were difficult to distinguish because of high background measurements and extremely low thyroid burdens, considerable information was gained in respect to the design and operation of the portable thyroid counter and the handling of public relations in obtaining the acceptance and cooperation of the offsite population.

Conclusion

In summary, three underground events and six reactor experiments released radioactivity to offsite areas. Of these, the Pin Stripe Event had the most apparent effect on the offsite environment, although radioactivity resulting from this event was detected in only negligible amounts in terms of established safety standards. Innovations in the development and use of surveillance equipment and control techniques were of particular significance.

Environmental radiation surveillance during this period indicates that no individual in the offsite area received an exposure resulting from NTS operations which exceeded the guides established by the AEC and/or recommended by the Federal Radiation Council.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for Atomics International, Los Alamos Scientific Laboratory and the Portsmouth Area Gaseous Diffusion Plant.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Atomics International [2] January-June 1971

North American Rockwell Corporation
Canoga Park, Calif.

Atomics International, a division of North American Rockwell Corporation, has engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, Calif., approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is located in the Simi Hills of Ventura County, approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

The basic concept of radiological hazard control at Atomics International requires adequate containment of radioactive materials and rigid operational controls to minimize effluent releases and external radiation levels. The environmental monitoring program provides a measure of the effectiveness of the company's radiological safety procedures and of engineering safeguards incorporated into facility designs.

The sites of the Atomics International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. The environs are sampled monthly, except for soil and vegetation which are sampled quarterly. Continuous environmental air monitoring at the sites provides information concerning long-lived airborne particulate radioactivity. A site perimeter radiation monitoring program using thermoluminescent dosimetry (TLD) was begun in 1971.

Counting and calibration procedures

The determination of radioactivity in all environmental soil, vegetation, water, and air samples is performed with a low-background proportional counting system capable of simultaneous counting of both alpha and net beta radioactivity. The sample-detector configuration provides a nearly 2π geometry. The thin-window detector is continually purged with methane counting gas. A preset time mode of operation is used for all samples; however, an overriding preset count mode is available to

[2] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1971 to June 30, 1971," Atomics International, Division of North American Rockwell Corporation.

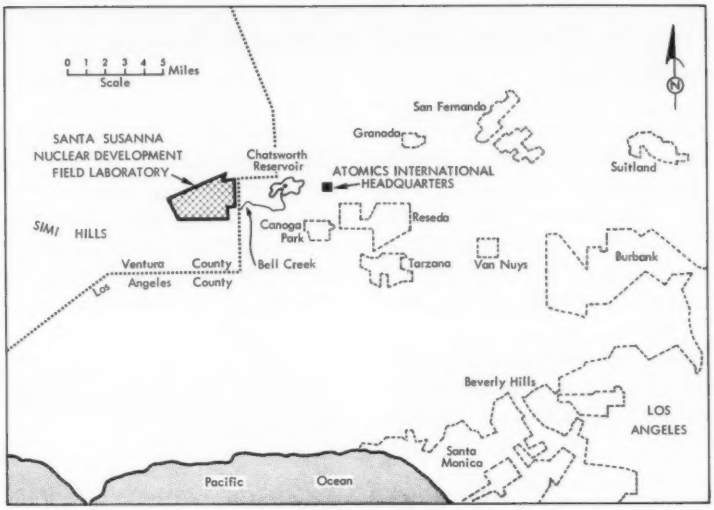

Figure 1. Atomics International facilities and vicinity

limit the counting time for high activity samples.

The minimum detection limits shown in table 1 were determined by using typical values for counting time, system efficiency, background count rates (approximately 0.05 cpm alpha and 1.0 cpm beta-gamma) and sample size. In addition, the minimum statistically significant amount of radioactivity, irrespective of sample configuration, is established as that amount equal in count rate to three times the standard deviation of the system background count rate.

Table 1. Minimum radioactivity detection limits, Atomics International

Sample	Radioactivity	Minimum detection limits (standard error)
Soil	Alpha	0.05 ±0.03 (pCi/g)
	Beta-gamma	.22 ± .11 (pCi/g)
Vegetation	Alpha	.10 ± .06 (pCi/g-ash)
	Beta-gamma	.35 ± .18 (pCi/g-ash)
Water	Alpha	.20 ± .12 (pCi/liter)
	Beta-gamma	.63 ± .32 (pCi/liter)
Air	Alpha	8.5 ±5.3 (fCi/m³)
	Beta-gamma	18 ±9.3 (fCi/m³)

Counting system efficiencies are determined routinely with RaD+E+F (with alpha absorber), thorium-230, and uranium-235 standard sources, and with potassium-40 in the form of standard reagent grade KCl, which is used to simulate soil and vegetation samples. Self-absorption standards are made by dividing sieved KCl into samples beginning with a 100 milligram sample and increasing in mass by 200-milligram increments from 200 to 3,000 milligrams. The samples are placed in copper planchets of the type used for environmental samples and counted. The ratio of sample activity to the observed net count rate for each sample is plotted as a function of sample weight (figure 2). The correction factor (ratio) corresponding to sample weight is obtained from the graph. The product of the correction factor and the net sample count rate yields the sample activity (dpm). This method has been proved usable by applying it to variously sized aliquots

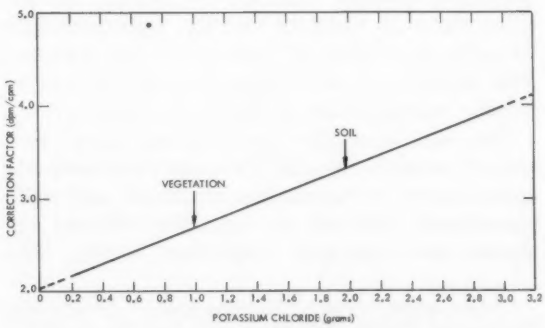

Figure 2. Sample self-absorption correction graph

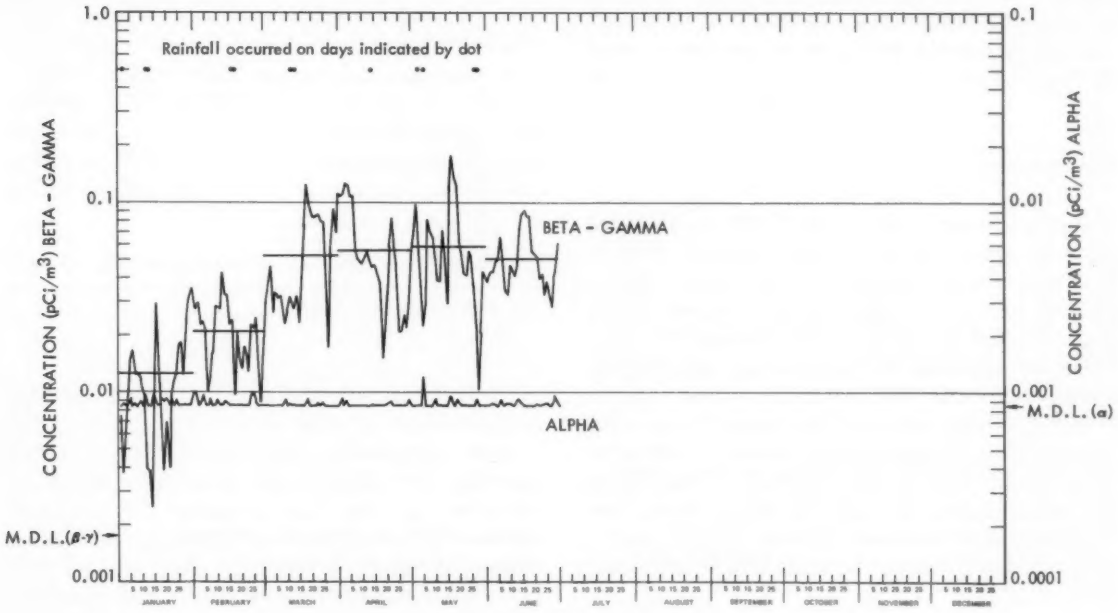

Figure 3. Long-lived radioactivity at headquarters and NDFL, January-June 1971

of uniformly mixed environmental samples and observing that the resultant specific activities fall within the expected statistical counting error.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic sequential air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV-70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20 cubic meters. The average concentration of long-lived beta-gamma radioactivity on airborne particulates is presented in table 2.

When abnormally high airborne radioactivities are observed, the beta-gamma radioactivity decay data are plotted to determine the presence of short-lived isotopes other than naturally occurring radon, thoron, and daughters. If fallout is suspected, the decay characteristics are observed. If the radioactivity decays as a function of $t^{-1.2}$, the data curve is extrapolated in order to determine the date of origin. This date is compared with the dates of publicized nuclear detonations to determine if the abnormal airborne radioactivity was caused by such detonations.

Table 2. Radioactivity in air, Atomics International January–June 1971

Location	Radioactivity	Number of samples	Average concentration (fCi/m³)
Headquarters	Alpha	362	8.7
	Beta-gamma	362	400
NDFL	Alpha	1,249	8.6
	Beta-gamma	1,249	440

A graph of averaged long-lived airborne radioactivity concentrations detected at the Headquarters and NDFL facilities during the first 6 months of 1971 is presented in figure 3.

The graph shows a generally increasing trend in airborne beta-gamma radioactivity through the spring months with a prominent peak noted in May.

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 3.

Table 3. Process water radioactivity, NDFL site January–June 1971

Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.32
Beta-gamma	12	4.9

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent Santa Susana Field Laboratory (SSFL) property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66-49, an environmental sampling station has been established in Bell Creek Canyon approximately 2.5 miles downstream from the south NDFL boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Table 4. Radioactivity in the Rocketdyne reservoir and Bell Creek,[a] January–June 1971

Sample description	Number of samples	Alpha radio-activity	Beta radio-activity
Reservoir (station 6), water [a] (pCi/liter)	6	0.24	6.1
Reservoir (station 12), water [a] (pCi/liter)	6	.16	6.2
Bell Creek (station 54), mud (pCi/g)	6	.31	23
Bell Creek (station 54), vegetation (pCi/g ash)	6	.19	161
Bell Creek (station 16), water (pCi/liter)	6	.20	3.9

[a] Location not shown on figure 1.

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The lake was drained in July 1969 for construction, thereby precluding surface sampling for the current reporting period. The average radioactivity concentration in reservoir supply water samples is presented in table 5.

Table 5. Chatsworth Reservoir water radioactivity Atomics International, January–June 1971

Sample	Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	0	—
	Beta-gamma	0	—
Supply inlet	Alpha	6	0.48
	Beta-gamma	6	6.1

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 25 locations. Eleven sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 14 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of undisturbed ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 6.

Table 6. Radioactivity in the soil, Atomics International January–June 1971

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.57
	Beta-gamma	72	25
Offsite	Alpha	24	.55
	Beta-gamma	24	24

Vegetation samples obtained in the field are of the same plant type wherever possible, generally, sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 7.

Table 7. Radioactivity in vegetation, Atomics International January–June 1971

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.25
	Beta-gamma	72	165
Offsite	Alpha	24	.26
	Beta-gamma	24	134

External radiation

Site boundary radiation monitoring is performed with calcium fluoride thermoluminescent dosimeters (TLD) placed at selected locations on or near the perimeters of the Headquarters and NDFL sites. Each dosimeter, sealed in a lightproof plastic holder, is installed in a polyethylene vial which is permanently mounted at each monitoring location. The dosimeters are exchanged and analyzed quarterly. The radiation dose monitored at each dosimeter location is presented in table 8.

Table 8. External radiation dose, Atomics International January–June 1971

Location	Dose (mrem)	Average dose rate (μrem/h)
TLD–1	97	24
TLD–2	67	16
TLD–3	90	22
TLD–4	99	24
TLD–5	81	20
TLD–6	84	21
TLD–7	99	24
TLD–8	108	27
TLD–9 [a]	39	18
TLD–10	132	32

[a] Second quarter only.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1970	February 1971
July-December 1970	June 1971

2. Los Alamos Scientific Laboratory [3] Calendar Year 1970

University of California
Los Alamos, N. Mex.

As part of the environmental monitoring program at Los Alamos, measurements of beta radioactivity in airborne particulates and precipitation are made periodically. The samples have been taken on the roof of building TA-50 (about 1¾ miles southeast of the administration building) since March 1963.

Air monitoring

Airborne radioactive particulate matter is collected on 4-inch-diameter filters. The air sampling rate is 17.0 m^3/h. Air samples are ordinarily collected for 24-hour intervals during the work week, and weekend samples are collected for a 72-hour period.

The filters are counted for beta radioactivity 7 days after collection in a thin-window gas

[3] Summarized from "Beta Radioactivity in Environmental Air and Precipitation at Los Alamos, New Mexico, for 1970" (La–4661).

Table 9. Beta radioactivity in air and precipitation, Los Alamos, January–December 1970

Month 1970	Air (pCi/m³)			Deposition (pCi/m³)			
	Maximum	Minimum	Average	Maximum	Minimum	Average	Total
January	0.10	0.02	0.06	72	1	12	369
February	.44	.06	.14	94	3	20	553
March	.32	.07	.18	559	3	105	3,258
April	1.01	.14	.42	673	2	64	1,993
May	1.19	.10	.38	452	11	63	1,972
June	.61	.16	.34	484	16	111	3,351
July	.30	.05	.12	555	5	125	3,865
August	.21	.03	.10	351	8	85	2,646
September	.14	.03	.08	643	5	83	2,491
October	.11	.01	.06	86	5	27	850
November	.28	.03	.10	72	2	16	496
December	.18	.05	.08	40	2	13	428

(methane) flow proportional counter with an overall efficiency of 50 percent for strontium-yttrium-90. A large chamber permits the air samples to be counted in the same geometry as the precipitation samples. The efficiency for strontium-yttrium-90 for the larger filter samples is also 50 percent.

Precipitation monitoring

Collection is made in a 0.4 square meter rain collector which delivers 1 liter of water for each 2.5 mm of precipitation. It has been found that this arrangement collected radioactivity even during relatively dry periods. By washing down the sides of the collector with 1 liter of distilled water, a suitable sample is obtained. Samples are taken daily on workdays. These "wash" samples, as well as any precipitation, are reduced in volume, dry-plated on 1-inch stainless-steel planchets, and counted in an automatic beta counting system, employing a gas-flow proportional alpha and beta chamber. A cosmic-ray umbrella with coincidence count-cancel provides a low background for the system. The counting efficiency is determined with a radiolead standard which emits 1.17 MeV beta particles.

Results

Average daily radioactivity concentrations in air are weighted for sample periods of more than 1 day. Average radioactivity concentrations for the precipitation collection are calculated from the total radioactivity collected during the month divided by the number of days in the month. Summary of air and precipitation data for January–December 1970 is presented in table 9.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January-June 1970	April 1971
July-December 1970	September 1971

3. Portsmouth Area Gaseous Diffusion Plant [4] January-June 1971

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. To verify the effectiveness of plant controls, environmental monitoring is conducted for evidence of alpha, beta, and gamma radiation, and it is assumed that the gross activity is due to enriched uranium and the beta-gamma radiation emanating from the thorium-234.

[4] Data summarized from "Portsmouth Area Gaseous Diffusion Plant Environmental Radioactivity Levels and Concentrations, Semiannual Summary, First half 1971" (September 17, 1971).

Table 10. Radioactivity in air, Portsmouth Plant, January–June 1971

Location	Number of samples	Alpha radioactivity concentration (fCi/m³)			Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/m³)			Average as a percent of AEC standards[a]
		Maximum	Minimum	Average		Maximum	Minimum	Average	
3	69	145	<16	32	0.80	1.66	<0.016	0.531	0.05
12	69	145	<16	32	.80	2.11	<.016	.531	.05
24	68	161	<16	32	.80	2.03	<.016	.564	.06
29	65	161	<16	32	.80	1.58	<.016	.515	.05
Summary	271	161	<16	32	.80	2.11	<.016	.538	.05

[a] The AEC radiation protection standard for alpha radioactivity in air–4 pCi/m³; beta-gamma radioactivity—1 nCi/m³; sensitivity of analysis for both alpha and beta radioactivity is 16.1 fCi/m³.

Table 11. Radioactivity in water, Portsmouth Plant, January–June 1971

Location	Number of samples	Alpha radioactivity concentration (pCi/liter)			Average as a percent of AEC standards[a]	Beta-gamma radioactivity concentration (pCi/liter)			Average as a percent of AEC standards[a]
		Maximum	Minimum	Average		Maximum	Minimum	Average	
1	6	13.5	0.5	4.1	0.01	31.5	6.8	13.5	0.07
2	6	63.0	.9	13.3	.04	18.0	6.8	8.6	.04
3[b]	6	3.2	.5	.8	.00	22.5	6.8	9.4	.05
4	6	13.5	.5	3.9	.01	58.5	6.8	19.9	.10
5	6	9.0	.5	4.4	.01	31.5	6.8	10.9	.05
6	6	10.8	.5	2.7	.00	81.9	6.8	21.2	.11
7	6	207	58.5	95.3	.32	1,410	104	644	3.22
8	6	122	36.0	78.8	.26	1,630	126	664	3.32
10[b]	6	9.0	.5	2.4	.00	49.5	6.8	15	.08
11[b]	6	329	99.0	208	.69	8,780	202	3,620	18.1
12	6	4.5	.5	1.3	.00	13.5	6.8	7.9	.04
13	6	31.5	.5	14.3	.05	266	6.8	104	.52
14	4	9.0	.5	4.4	.01	40.5	6.8	20.3	.10
Summary	76	329	0.5	33.4		8,780	6.8	397	

[a] The AEC radiation protection standard for alpha radioactivity in water—30 nCi/liter; beta-gamma radioactivity—20 nCi/liter; sensitivity of analysis alpha radioactivity—0.5 pCi/liter; beta radioactivity—14.0 pCi/liter.
[b] Composite sample.

Air samples are collected three times each week at four locations. Each sample, consisting of approximately 1,000 cubic feet of air, is passed through a Whatman 41 filter paper at about 20 cubic feet per minute. The material collected on the filter paper is analyzed for gross alpha and gross beta-gamma activities.

Two sampling procedures are used for water analyses. One-half gallon samples are taken monthly from the Scioto River and its tributaries, Little Beaver Creek, Big Beaver Creek, and Big Run. Composite samples are collected continuously (or at specific intervals) from the three principal drainage ditches serving the plant; sampling locations are identified as points 3, 10, and 11 (figure 4). The composite samples are collected in 55-gallon drums. Once each month, the water in the drum is drained and installed again in the collection system. The one-half gallon samples are analyzed for average gross alpha and beta-gamma radioactivity concentrations.

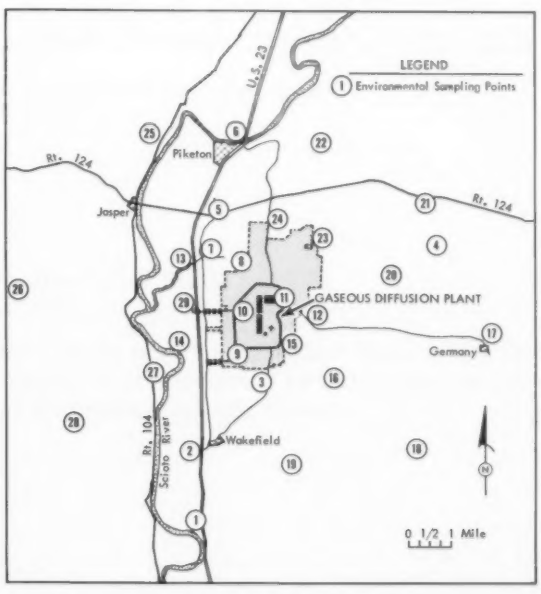

Figure 4. Sampling locations, Portsmouth Area Gaseous Diffusion Plant

In addition to the water samples, external gamma radiation levels are measured routinely at locations 3, 12, 24, and 29. Measurements are made three times each week with a calibrated Geiger-Mueller tube at a distance 3 feet above ground level.

Average alpha and beta-gamma radioactivity concentrations in air are summarized in table 10. Table 11 contains the average alpha and beta-gamma radioactivity concentrations in water. The external gamma-ray level, measured at the sampling locations shown in figure 4, are summarized in table 12.

The maximum radioactivity in water is persistently found in samples taken from the east drainage ditch, sampling location 11; and the other high values are found in samples taken downstream from sample point 11.

Table 12. Background exposure rates, Portsmouth Plant, January–June 1971

Location	Number of samples	Background rate [a] (μrem/h)		
		Maximum	Minimum	Average
3	62	19.0	7.4	10.9
12	63	12.9	6.0	9.8
24	64	26.9	7.6	11.4
29	60	18.1	7.6	11.9
Summary	249	26.9	6.0	11.0

[a] Open-shield geiger tube 1 foot above ground; limit of sensitivity—0.1 μrem/h.

Sample location 11 is in the east drainage ditch before the ditch dumps into Little Beaver Creek. Sampling point 8 is in Little Beaver Creek a short distance above its confluence with the Big Beaver Creek; and sample location 7 is in Little Beaver Creek immediately above the confluence of the two creeks. Location 13 is in Big Beaver Creek below the confluence of Big Beaver and Little Beaver Creeks. Location 14 provides samples from the Scioto River after it is joined by Big Beaver Creek.

The samples taken from locations 7 and 8 would be expected to be quite similar, and indeed the radioactivity concentrations are similar. As one would expect then, the radioactivity concentrations decrease rapidly in going from point 11, through 7–8, through 13, and eventually to 14. Based on results from location 6 (in the Scioto River above its confluence with Big Beaver Creek) and location 14, it is evident that the Scioto River has not suffered pollution from the Portsmouth Gaseous Diffusion Plant.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1970	April 1971
July–December 1970	September 1971

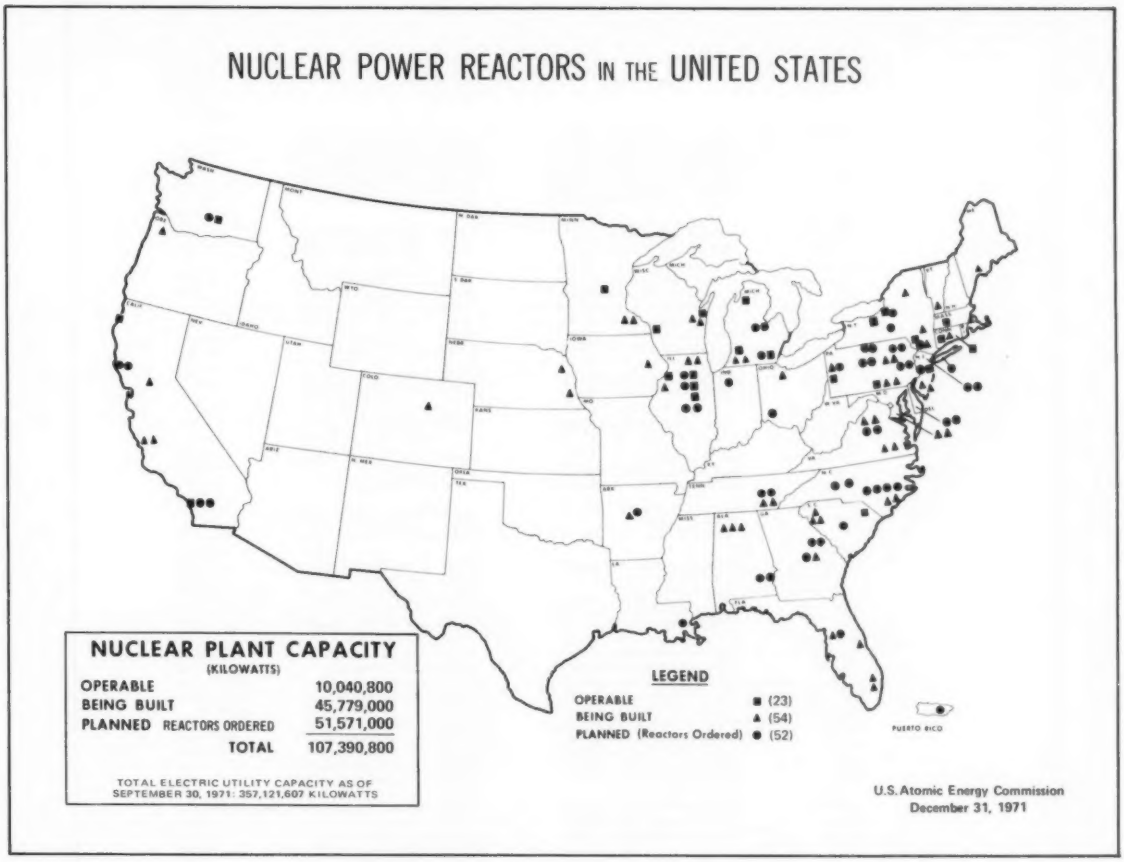

Figure 1. Nuclear power reactors in the United States, December 31, 1971

Nuclear Power Reactors in the United States December 31, 1971

Each quarter year, the Atomic Energy Commission releases information on the status of all present and proposed civilian nuclear power generating units in the United States. This information is reproduced for interested readers of Radiation Data and Reports.

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
ALABAMA				
Decatur	Browns Ferry Nuclear Power Plant: Unit 1	1,065,000	Tennessee Valley Authority	1972
Decatur	Browns Ferry Nuclear Power Plant: Unit 2	1,065,000	Tennessee Valley Authority	1973
Decatur	Browns Ferry Nuclear Power Plant: Unit 3	1,065,000	Tennessee Valley Authority	1973
Dothan	Joseph M. Farley Nuclear Plant: Unit 1	829,000	Alabama Power Co.	1975
Dothan	Joseph M. Farley Nuclear Plant: Unit 2	829,000	Alabama Power Co.	1977
ARKANSAS				
Russellville	Arkansas Nuclear One: Unit 1	820,000	Arkansas Power & Light Co.	1973
Russellville	Arkansas Nuclear One: Unit 2	920,000	Arkansas Power & Light Co.	1975
CALIFORNIA				
Humboldt Bay	Humboldt Bay Power Plant: Unit 3	68,500	Pacific Gas and Electric Co.	1963
San Clemente	San Onofre Nuclear Generating Station: Unit 1	430,000	So. Calif. Ed. & San Diego Gas & El. Co.	1967
San Clemente	San Onofre Nuclear Generating Station: Unit 2	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
San Clemente	San Onofre Nuclear Generating Station: Unit 3	1,140,000	So. Calif. Ed. & San Diego Gas & El. Co.	—
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 1	1,060,000	Pacific Gas and Electric Co.	1974
Diablo Canyon	Diablo Canyon Nuclear Power Plant: Unit 2	1,060,000	Pacific Gas and Electric Co.	1975
Clay Station	Rancho Seco Nuclear Generation Station	804,000	Sacramento Municipal Utility District	1973
Pt. Arena	Mendocino Power Plant: Unit 1	1,128,000	Pacific Gas & Electric Co.	1978
Pt. Arena	Mendocino Power Plant: Unit 2	1,128,000	Pacific Gas & Electric Co.	1979
COLORADO				
Platteville	Ft. St. Vrain Nuclear Generating Station	330,000	Public Service Co. of Colorado	1972
CONNECTICUT				
Haddam Neck	Haddam Neck Plant	575,000	Conn. Yankee Atomic Power Co.	1967
Waterford	Millstone Nuclear Power Station: Unit 1	652,100	Northeast Utilities	1970
Waterford	Millstone Nuclear Power Station: Unit 2	828,000	Northeast Utilities	1974
DELEWARE				
•	Delmarva Unit 1	770,000	Delmarva Power & Light Co.	1979
•	Delmarva Unit 2	770,000	Delmarva Power & Light Co.	1982
FLORIDA				
Turkey Point	Turkey Point Station: Unit 3	693,000	Florida Power & Light Co.	1971
Turkey Point	Turkey Point Station: Unit 4	693,000	Florida Power & Light Co.	1972
Red Level	Crystal River Plant: Unit 3	825,000	Florida Power Corp.	1973
Red Level	Crystal River Plant: Unit 4	897,000	Florida Power Corp.	1978
Ft. Pierce	Hutchinson Island: Unit 1	800,000	Florida Power and Light Co.	1974
GEORGIA				
Baxley	Edwin I. Hatch Nuclear Plant: Unit 1	786,000	Georgia Power Co.	1973
Baxley	Edwin I. Hatch Nuclear Plant: Unit 2	786,000	Georgia Power Co.	1976
Hancock Landing	Alvin W. Vogtle, Jr. Plant: Unit 1	1,100,000	Georgia Power Co.	1978
Hancock Landing	Alvin W. Vogtle, Jr. Plant: Unit 2	1,100,000	Georgia Power Co.	1979
ILLINOIS				
Morris	Dresden Nuclear Power Station: Unit 1	200,000	Commonwealth Edison Co.	1960
Morris	Dresden Nuclear Power Station: Unit 2	809,000	Commonwealth Edison Co.	1970
Morris	Dresden Nuclear Power Station: Unit 3	809,000	Commonwealth Edison Co.	1971
Zion	Zion Nuclear Plant: Unit 1	1,050,000	Commonwealth Edison Co.	1972
Zion	Zion Nuclear Plant: Unit 2	1,050,000	Commonwealth Edison Co.	1973
Cordova	Quad-Cities Station: Unit 1	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1971
Cordova	Quad-Cities Station: Unit 2	809,000	Comm. Ed. Co.-Ia.-Ill. Gas & Elec. Co.	1972
Seneca	LaSalle Co. Nuclear Station: Unit 1	1,078,000	Comm. Ed. Co.-Ia.	1975
Seneca	LaSalle Co. Nuclear Station: Unit 2	1,078,000	Comm. Ed. Co.-Ia.	1976
•	—	1,100,000	Comm. Edison Co.	1978
•	—	1,100,000	Comm. Edison Co.	1979
INDIANA				
Dune Acres	Bailly Generating Station	660,000	Northern Indiana Public Service Co.	1976
IOWA				
Cedar Rapids	Duane Arnold Energy Center: Unit 1	529,700	Iowa Electric Light and Power Co.	1973
LOUISIANA				
Taft	Waterford Generating Station: Unit 1	1,165,000	Louisiana Power & Light Co.	1976
MAINE				
Wiscasset	Maine Yankee Atomic Power Plant	790,000	Maine Yankee Atomic Power Co.	1972
MARYLAND				
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 1	845,000	Baltimore Gas and Electric Co.	1973
Lusby	Calvert Cliffs Nuclear Power Plant: Unit 2	845,000	Baltimore Gas and Electric Co.	1974
MASSACHUSETTS				
Rowe	Yankee Nuclear Power Station	175,000	Yankee Atomic Electric Co.	1961
Plymouth	Pilgrim Station	655,000	Boston Edison Co.	1972
MICHIGAN				
Big Rock Point	Big Rock Point Nuclear Plant	70,300	Consumers Power Co.	1963
South Haven	Palisades Nuclear Power Station	700,000	Consumers Power Co.	1971
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 1	60,900	Detroit Edison Co.	1970
Lagoona Beach	Enrico Fermi Atomic Power Plant: Unit 2	1,123,000	Detroit Edison Co.	1974
Bridgman	Donald C. Cook Plant: Unit 1	1,054,000	Indiana & Michigan Electric Co.	1973
Bridgman	Donald C. Cook Plant: Unit 2	1,060,000	Indiana & Michigan Electric Co.	1974
Midland	Midland Nuclear Power Plant: Unit 1	492,000	Consumers Power Co.	1976
Midland	Midland Nuclear Power Plant: Unit 2	818,000	Consumers Power Co.	1977
MINNESOTA				
Monticello	Monticello Nuclear Generating Plant	545,000	Northern States Power Co.	1971
Red Wing	Prairie Island Nuclear Generating Plant: Unit 1	530,000	Northern States Power Co.	1972
Red Wing	Prairie Island Nuclear Generating Plant: Unit 2	530,000	Northern States Power Co.	1974
NEBRASKA				
Fort Calhoun	Ft. Calhoun Station: Unit 1	457,400	Omaha Public Power District	1973
Brownville	Cooper Nuclear Station	778,000	Nebraska Public Power District and Iowa Power and Light Co.	1973

Figure 1. Nuclear power reactors in the United States, December 31, 1971—continued

SITE	PLANT NAME	CAPACITY (Net Kilowatts)	UTILITY	INITIAL DESIGN POWER
NEW JERSEY				
Toms River	Oyster Creek Nuclear Power Plant: Unit 1	650,000	Jersey Central Power & Light Co.	1969
Forked River	Forked River Generating Station: Unit 1	1,140,000	Jersey Central Power & Light Co.	1977
Salem	Salem Nuclear Generating Station: Unit 1	1,090,000	Public Service Electric and Gas, N. J.	1973
Salem	Salem Nuclear Generating Station: Unit 2	1,115,000	Public Service Electric and Gas, N. J.	1974
Bordentown	Newbold Nuclear Generating Station: Unit 1	1,088,000	Public Service Electric and Gas, N. J.	1975
Bordentown	Newbold Nuclear Generating Station: Unit 2	1,088,000	Public Service Electric and Gas, N. J.	1977
NEW YORK				
Indian Point	Indian Point Station: Unit 1	265,000	Consolidated Edison Co.	1963
Indian Point	Indian Point Station: Unit 2	873,000	Consolidated Edison Co.	1972
Indian Point	Indian Point Station: Unit 3	965,000	Consolidated Edison Co.	1973
Scriba	Nine Mile Point Nuclear Station: Unit 1	625,000	Niagara Mohawk Power Co.	1970
Scriba	Nine Mile Point Nuclear Station: Unit 2	1,100,000	Niagara Mohawk Power Co.	1977
Rochester	R. E. Ginna Nuclear Power Plant: Unit 1	420,000	Rochester Gas & Electric Co.	1970
Brookhaven	Shoreham Nuclear Power Station	819,000	Long Island Lighting Co.	1975
Lansing	Bell Station	838,000	New York State Electric & Gas Co.	1978
Verplanck	Con. Ed. Nuclear #4	1,115,000	Consolidated Edison Co.	1977
Scriba	James A. Fitzpatrick Nuclear Power Plant	821,000	Power Authority of State of N. Y.	1973
NORTH CAROLINA				
Southport	Brunswick Steam Electric Plant: Unit 1	821,000	Carolina Power and Light Co.	1975
Southport	Brunswick Steam Electric Plant: Unit 2	821,000	Carolina Power and Light Co.	1974
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 1	1,150,000	Duke Power Co.	1975
Cowans Ford Dam	Wm. B. McGuire Nuclear Station: Unit 2	1,150,000	Duke Power Co.	1977
Bonsal	Shearon Harris Plant: Unit 1	915,000	Carolina Power & Light Co.	1977
Bonsal	Shearon Harris Plant: Unit 2	915,000	Carolina Power & Light Co.	1978
Bonsal	Shearon Harris Plant: Unit 3	915,000	Carolina Power & Light Co.	1979
Bonsal	Shearon Harris Plant: Unit 4	915,000	Carolina Power & Light Co.	1980
OHIO				
Oak Harbor	Davis-Besse Nuclear Power Station	872,000	Toledo Edison-Cleveland Electric Illuminating Co.	1974
Moscow	Wm. H. Zimmer Nuclear Power Station: Unit 1	810,000	Cincinnati Gas & Electric Co.	1974
OREGON				
Prescott	Trojan Station	1,130,000	Portland General Electric Co.	1974
PENNSYLVANIA				
Peach Bottom	Peach Bottom Atomic Power Station: Unit 1	40,000	Philadelphia Electric Co.	1967
Peach Bottom	Peach Bottom Atomic Power Station: Unit 2	1,065,000	Philadelphia Electric Co.	1973
Peach Bottom	Peach Bottom Atomic Power Station: Unit 3	1,065,000	Philadelphia Electric Co.	1974
Pottstown	Limerick Generating Station: Unit 1	1,065,000	Philadelphia Electric Co.	1975
Pottstown	Limerick Generating Station: Unit 2	1,065,000	Philadelphia Electric Co.	1977
Shippingport	Shippingport Atomic Power Station: Unit 1	90,000	Duquesne Light Co.	1957
Shippingport	Beaver Valley Power Station: Unit 1	847,000	Duquesne Light Co.-Ohio Edison Co.	1973
Shippingport	Beaver Valley Power Station: Unit 2	847,000	Duquesne Light Co.-Ohio Edison Co.	1978
Middletown	Three Mile Island Nuclear Station: Unit 1	831,000	Metropolitan Edison Co.	1973
Middletown	Three Mile Island Nuclear Station: Unit 2	907,000	Jersey Central Power & Light Co.	1975
Berwick	Susquehanna Steam Electric Station: Unit 1	1,052,000	Pennsylvania Power and Light	1978
Berwick	Susquehanna Steam Electric Station: Unit 2	1,052,000	Pennsylvania Power and Light	1980
*	Philadelphia Electric Co.: HTGR No. 1	1,150,000	Philadelphia Electric Co.	1979
*	Philadelphia Electric Co.: HTGR No. 2	1,150,000	Philadelphia Electric Co.	1981
SOUTH CAROLINA				
Hartsville	H. B. Robinson S. E. Plant: Unit 2	700,000	Carolina Power & Light Co.	1971
Seneca	Oconee Nuclear Station: Unit 1	841,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 2	886,000	Duke Power Co.	1972
Seneca	Oconee Nuclear Station: Unit 3	886,000	Duke Power Co.	1973
Parr	Virgil C.Summer Nuclear Station: Unit 1	900,000	South Carolina Electric & Gas Co.	1977
TENNESSEE				
Daisy	Sequoyah Nuclear Power Plant: Unit 1	1,124,000	Tennessee Valley Authority	1974
Daisy	Sequoyah Nuclear Power Plant: Unit 2	1,124,000	Tennessee Valley Authority	1974
Spring City	Watts Bar Nuclear Plant: Unit 1	1,169,000	Tennessee Valley Authority	1976
Spring City	Watts Bar Nuclear Plant: Unit 2	1,169,000	Tennessee Valley Authority	1977
VERMONT				
Vernon	Vermont Yankee Generating Station	513,900	Vermont Yankee Nuclear Power Corp.	1971
VIRGINIA				
Gravel Neck	Surry Power Station: Unit 1	788,000	Virginia Electric & Power Co.	1972
Gravel Neck	Surry Power Station: Unit 2	788,000	Virginia Electric & Power Co.	1972
Mineral	North Anna Power Station: Unit 1	845,000	Virginia Electric & Power Co.	1974
Mineral	North Anna Power Station: Unit 2	845,000	Virginia Electric & Power Co.	1975
Mineral	North Anna Power Station: Unit 3	900,000	Virginia Electric & Power Co.	1977
Mineral	North Anna Power Station: Unit 4	900,000	Virginia Electric & Power Co.	1978
WASHINGTON				
Richland	N-Reactor/WPPSS Steam	800,000	Atomic Energy Commission	1966
Richland	Hanford No. 2	1,110,000	Washington Public Power Supply System	1977
WISCONSIN				
Genoa	Genoa Nuclear Generating Station	50,000	Dairyland Power Cooperative	1969
Two Creeks	Point Beach Nuclear Plant: Unit 1	497,000	Wisconsin Michigan Power Co.	1971
Two Creeks	Point Beach Nuclear Plant: Unit 2	497,000	Wisconsin Michigan Power Co.	1971
Carlton	Kewaunee Nuclear Power Plant: Unit 1	541,000	Wisconsin Public Service Co.	1972
PUERTO RICO				
Puerto De Jobas	Aguirre Nuclear Power Plant	583,000	Puerto Rico Water Resources Authority	1975
*	—	1,175,000	Tennessee Valley Authority	1977
*	—	1,175,000	Tennessee Valley Authority	1978

* Site not selected.

Figure 1. Nuclear power reactors in the United States, December 31, 1971—continued

Reported Nuclear Detonations, January 1972

(Includes seismic signals presumably from foreign nuclear detonations)

The Peoples Republic of China set off a nuclear explosion in the atmosphere at approximately 2:00 a.m., EST, on January 7, 1972, at their Lop Nor nuclear test area in northwest China. The yield was less than 20 kilotons.

There were no reported nuclear detonations for the United States for January 1972.

Information in this section is based on data received during the month, and is subject to change as additional information may become available. Persons requiring information for purposes of compiling announced nuclear detonation statistics are advised to contact the Division of Public Information, U.S. Atomic Energy Commission, Washington, D.C. 20545.

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

EVALUATION OF TRITIUM IN GROUND AND SURFACE WATERS OF THE WESTERN UNITED STATES, APRIL 1968-DECEMBER 1969. *James W. Mullins and John L. Stein, Radiation Data and Reports, Vol. 13, February 1972, pp. 59–67.*

In order to establish a baseline for environmental tritium so that any future deviations could be evaluated, a study was conducted to measure current levels of tritium in ground and surface waters of the Western United States. Data are reported for tritium concentrations in surface and ground waters during April 1968-December 1969 in the Western United States including Alaska and Hawaii. Samples were collected by State public health agencies and mailed to the Western Environmental Research Laboratory where they were analyzed by liquid scintillation techniques. The concentration of tritium was nondetectable in most ground water samples, while other samples contained as much as 2.6 nCi/liter. Surface water samples ranged from nondetectable to 3.8 nCi/liter. Possible reasons for the range of results, such as altitude and latitude effects, are discussed.

KEYWORDS: Ground water, surface water, tritium, water, Western United States.

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